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WORLD POPULATION AND RESOURCES

THE impact of science on technology—in particular, military technology—and, through it, on the national and international fortunes of the Western world have been the main concern of the *Bulletin* for five years. In the world-historical perspective, another consequence of the "scientific age" for human society may prove even more decisive. This is the accelerated growth of the world's population made possible by the spread of modern medical science to pastoral and agrarian areas of the world and the challenge this growth poses to the industrial and agricultural progress of mankind.

In this issue we print three articles, representing the views of a demographer and of two agricultural scientists. The first one is by Frank W. Notestein, a prominent demographer who is Director of the Office of Population Research at Princeton University.

In the past, demography dealt mainly with population trends in single countries or areas, such as Western Europe or North America. Now, enough data has begun to accumulate to permit an analysis of the problem of world population as a whole. Before the two world wars, the main demographic worry of the Western world was the apparent tendency of the most advanced nations toward stabilization or even slow retrogression. France, whose population became stationary at the beginning of the present century, was held out to other Western peoples as an object lesson in "degeneracy." Many in the West were frightened at the prospect of the rapidly multiplying Oriental nations swamping the Western world.

Since then the point of view has shifted. The rapid growth of population in East Asia and South America still appears to be a danger to the stability and prosperity of mankind. At the present time, however, emphasis is not on this expanding population as a military or political threat to the security of the West, rather it is on the obstacle this rapid growth constitutes to an increase in prosperity of the rapidly multiplying populations themselves.

Unless the passive acceptance of Western health standards is supplemented by active transformation of the age-old patterns of living—by converting pastoral and agrarian peoples with their ideal of unlimited propagation into urbanized industrial communities, where quality replaces quantity as a yardstick of successful perpetuation of the family—demographers can see little chance that the gain of world agricultural production will ever overtake the swell of rising populations. If this should be so, then continued undernourishment and penury lies ahead for these countries and little hope is left for the termination of the unrest presently engulfing large parts of the world and for the gradual development of those areas along democratic lines.

Those who come to look on the same situation from a background of study of industrial or agricultural technology, rather than of population statistics, often are inclined to be less pessimistic. Even if they cannot help recognizing the horns of the dilemma, they are loath to believe that science and technology should prove unable to compound a rational formula for its solution using as ingredients accelerated increase of food production, industrialization of agriculture, and transformation of traditional attitudes through education and of national habits through industrialization. This more optimistic view was represented in one of the past issues of the *Bulletin* by the Harvard anthropologist, Kirtley Mather,[1] and is again advanced in this issue by the agricultural authority, Dennis A. Fitzgerald of the ECA. Karl Sax, the prominent Harvard horticulturist, is not so hopeful; his estimate is more strongly influenced by population statistics, and he is more acutely concerned with the limitations of the presently discernible ways to raise world food production.

We hope that these three articles will be but an introduction to a more detailed symposium on the subject of World Needs and World Resources. Population trends and agricultural production are, after all, but two elements of the complex situation—albeit the most obvious ones. Industrial energy resources and the possible changes of popular attitudes through education are among other important factors which call for examination and affect prognosis.

—E. R.

[1] Kirtley Mather, "The Social Implications of Science," *Bulletin*, VI (July 1949), 207–12.

THE NEEDS OF WORLD POPULATION

FRANK W. NOTESTEIN

In this first article, Dr. Notestein, an authority on demography, of the Office of Population Research at Princeton University, points out the consequences of attempting to increase the life expectancy of people in nonindustrialized countries without regard for the resulting population growth.

ON THE face of it, my task of assessing the needs of world population is a simple one. All I have to do is to draw up a huge bill of anticipated human needs. Mr. Fitzgerald will then have to try to find the means for footing the bill. Unfortunately, this approach to our problem is not realistic. One of the elements that will determine human needs a few decades from now will be the number of people then alive, and the number of inhabitants of the globe a generation from now, in its turn, is going to depend to a considerable extent on the trend of the death rate over the next three decades. The latter, in turn, will be influenced by the amount and nature of economic production during these years. So, the human needs a generation from now are going to depend very largely on the volume of production achieved between now and then. It would thus seem that instead of my presenting Mr. Fitzgerald with a bill of needs, he must tell me what our income is going to be so that I can tell him how much life he can expect to buy with that income. However, this approach to the matter is just as unrealistic as the first one.

Too many discussions have taken one or the other of these two lines, neither of which is adequate. There is no inevitable course of population growth. The rate of growth of the world's population will be determined by the future trend of birth and death rates. These, in turn, will be strongly influenced by changes in the food supply, industrial production, sanitary conditions, education, the role and status of women—indeed, by changes in all aspects of the social, economic, and political life. On the other hand, neither will economic production, the utilization of available resources, nor, indeed, the very definition of what constitutes such resources, be independent of the social-economic organization and the number and characteristics of the people, who are both the producers and the consumers. If we endeavor to treat resources and needs, or the supply and demand aspects of the problem, as independent of each other, we shall get nowhere. A meaningful approach to our problem requires constant awareness that we are dealing with a tightly interrelated process of social, economic, and population change, in which there are no completely independent variables.

Therefore, my task is not that of telling you how many people we may expect to inhabit the world a generation from now and enumerating their needs. It is the much more difficult job of considering the processes of population change in relation to those of social and economic development to obtain an idea of the troubles which may lie ahead, and some judgment about the ways in which energies can be strategically applied to minimize those difficulties.

THE MAIN OBJECTIVE: BETTER HEALTH

Perhaps the best way of approaching the subject is first to define our objectives. I am going to assume that our main aim is to secure better health for the world's population, and that our secondary aim, and a means of obtaining the primary one, is to secure higher levels of material well-being throughout the world. Other objectives are equally tenable from a logical point of view. For example, the aim might be to get the maximum number of people going to heaven in a minimum length of time. Sometimes it seems as if the modern world has been devoting its major energies to this end. Given certain premises, such a goal is logical. It suffers, however, from one grave defect. Those who seem most interested in populating a future world usually prefer to have someone else undertake the migration, and seldom hasten their personal journey. The goals of better health and higher levels of living at least have the virtue of being, once they are understood, almost universally desired by the individual—for himself and for those to whom he is most intimately tied. I shall not discuss whether it is a good thing to improve health and material welfare, but I shall assume it.

THE PROBLEM OF GROWTH

Another question that often consumes much time in discussions is the size of the population the earth can support. This is an excellent topic for intricate and rather futile debate, as a moment's reflection will show.

There are about two and one-third billion men, women, and children alive today. Three centuries ago, the number stood at something like one-half billion. In the last one hundred years,

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Based on a speech given at the Northwestern University Centennial Conference on Science, Technology, and World Resources on March 1, 1951.

the world's population has more than doubled. In recent decades, in spite of two world wars of unexampled destructiveness, the rate of growth has risen to about 1 per cent per year. This rate doubles a population in sixty-nine years. It requires no complicated calculations to show that such an increase could not be maintained for any span of time that is significant in the history of the human race. For example, a rate of increase of only one-half of 1 per cent, maintained for another two thousand years, would leave less than four square yards of the earth's land surface for each person. If such growth were to continue for one one-hundredth of the time it has taken mankind to reach its present numbers, no standing room would be left on earth, without a huge interplanetary migration.

Such calculations are, of course, perfectly accurate—and perfectly useless, except for one thing. They demonstrate a principle that many people are unwilling to face. Sustained population growth, even at a relatively low rate, is not possible for any period of time significant in the history of the human race. In principle, there must come a time at which low death rates could not be maintained without comparably low birth rates. This is an inexorable fact of nature. In the long run, birth and death rates must be in approximate balance. Those who say that there is no need for such a balance can only mean that there is no need for such a balance now, or within some span of years to which they personally attach importance. The principle remains. Eventually, population growth must end. Barring interplanetary migration, it can end only in one or both of two ways. Death rates must rise, or birth rates must fall. Since we have assumed better health as our objective, we must elect the decline of the birth rate as our aim. Our problem then is not how much population the world will hold. The fundamental problem is that of attaining the low birth rates that will permit a sustained maintenance of low death rates. Or, put another way, it is the problem of substituting an efficient system of maintaining human life by a balance of low birth and death rates for the present grossly inefficient system.

If, in the very long run, low birth rates must be attained in order to sustain the low death rates that modern technology makes possible, the only issue is that of timing. The change must come eventually; how soon is it needed? Here we face two questions. Are larger populations needed as a means of attaining better health? And, if larger numbers are not positively needed, would they at least constitute no obstacle to the attainment of that goal?

The first problem is relatively simple. Since good health can be shown to require higher levels of living, we have only to ask whether a larger world population would facilitate an increase in per capita production. From this point of view, the only advantage that comes from larger numbers *as such* is to be found in the economies that can be achieved in the productive process by means of additional specialization. It would take a rash person to argue that the world's present failure to reap the full advantages of specialization in production depends in any significant part on the fact that there are only two and one-third billion people. Certainly, the world's poverty is not due to its small population. Rather it is due to an inappropriate distribution of people in relation to resources, and to the inadequacies of mankind's social, economic, and political arrangements. From the point of view of improving living conditions as a means of attaining better health, the world already has ample population. Thus far, we have said only that there is no need for additional numbers as such. It is still possible that additional population growth would involve no great penalties in the foreseeable future. If this were the case, the question of population growth would not be of immediate importance.

This question is much more difficult to meet. There are vast unused resources in the world, and new developments in technology will certainly add to these resources, as well as make heavy drafts upon them. For our present purposes, about all that needs to be said is that there are hundreds of millions of people currently eking out a pitiful subsistence, because their productive efforts are supplemented by too little capital and too little land. Any change that would provide more adequate capital and land to those now inadequately supplied would make huge drains on our stock of unused resources. Since some of the resources are scarce, and since substitutes are expensive, there is obvious danger that a greatly expanded population would increase the costs of production, and thus become an obstacle to the attainment of higher levels of living. The least one can say is that the prudent man, interested in improving health, would want adequate living conditions for the present population, before glibly asserting that no difficulties can be foreseen in doubling or trebling existing numbers.

Quite apart from the problems presented by the size of the population the growth process itself can cause difficulties. A population that is growing by 2 per cent per year, for instance, must expand its durable facilities and consumption goods at the same rate merely to avoid deterioration of living conditions. Rapid population growth may in the future, as it often has in the past, absorb a major part of additional production yielded by economic development, and leave larger populations with only slightly improved living conditions.

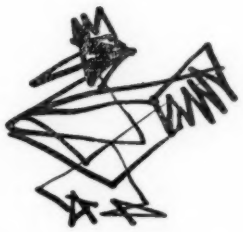
We have indicated thus far that additional population will not of itself help to attain better health; but we have been much less definite about the degree to which additional population growth might restrict improvements in health. On this issue, we have suggested only that there are difficult problems in absorbing rapid growth, and that the prospect of another doubling or trebling of population could not be viewed with equanimity. In fact, we do not need a very precise answer to this question, if man's health improves in the future at anything like the rate it has improved during recent decades. Under these conditions the human race would be very lucky indeed to attain an equilibrium based on low birth and low death rates, with a mere doubling of its present numbers.

I want to be quite clear on this point. I am not predicting that the world's population is going to double in the next century. For all I know life on this planet may be extinct in a hundred years, or a period of war and social disorganization may lift death rates so high that no increase in population will occur. In the present discussion, however, we are speaking of human

needs, presumably on the assumption that something can be done about fulfilling them. I have defined these needs in terms of better health. It is, therefore, incumbent upon me to face the consequences of the successful improvement of health. My point is that population may or may not grow, but that if we are successful in attaining better health for the world's people, the population almost certainly will grow. Moreover, such growth might well more than double the present world population before it is checked by low birth rates. Under these circumstances there is a serious possibility that the speed and magnitude of growth will curtail average income and, in turn, force death rates up, thereby re-establishing the old equilibrium of growth checked by poverty and high death rates.

Let us examine the potentialities for population increase inherent in the assumption that health continues to improve. In most of the technologically advanced nations of the world, health is remarkably good in terms of anything to which mankind has hitherto been accustomed. A perpetuation of the risks of death current in the technologically advanced countries, would permit one-half of those born to live for more than seventy years. The populations of the technologically advanced nations are increasing, and may continue to do so for a considerable time; but, we need not devote much attention to them because their fertility, too, is under strong rational control. Any time population growth threatens their well-being, in a generally recognizable way, growth is curtailed by a reduction of births. These nations are in no danger of becoming dependent on rising death rates to keep their population increase in check.

Other countries, such as the Soviet Union, Japan, and the nations of Eastern Europe, are in a less advanced position. Here again, except for the special case of Japan, population increase presents no grave obstacles to the attainment of better health if the economies are adequately developed. Moreover, there is evidence that in several decades, and after a considerable expansion of population, low birth rates may be expected to check growth in these countries. Declining birth rates have already made their appearance. In some other parts of the world where birth rates are now at the very high levels that characterize most of premodern societies, the populations still are relatively small in relation to resources. Growth yielded by declining death rates, if it is not too rapid, could be absorbed for a considerable time, provided there is rapid economic development. Such areas include much of the Middle East, Africa, and South America. In all the regions thus far discussed, improving health conditions might very easily more than double the present population within a century; but it seems unlikely that poverty from the pressure of population will force death rates up before there is an opportunity for transition to low birth rates.



It is in the remainder of the world that the problems of population growth are presented in their most acute form. This remainder includes such areas as the islands of the Caribbean, Egypt, the non-Soviet Far East, India, and Southeast Asia, which taken together contain more than one-half of the world's population. Throughout most of these areas populations are relatively densely settled in spite of underdeveloped and inadequate resources. Birth rates are almost universally very high. Death rates range from very high to remarkably low, considering the unfavorable circumstances. Growth, therefore, ranges from slow to rather rapid. China, for example, may not have grown much during the recent years of turmoil. India and Pakistan have increased at a rather slow rate because death rates have been very high. However, even these slow rates of growth have yielded enormous absolute increases because the base populations were so large. In just twenty years, from 1921 to 1941, the population of the Indian peninsula increased by 83 million—a number larger than the total population of the United States in 1900. Puerto Rico, Egypt, Japan, Korea, Formosa, and Java have grown even more rapidly.

At the moment, however, we are less concerned with past increases than with increases to be expected on the assumption of improving health. We have no reason to believe that there are fewer than 40 births a year for every thousand people in this group. The real figure is probably somewhat higher. Death rates may well be higher than 30 on the average, and the rate of growth may be less than 10 per thousand or 1 per cent per year. But death rates of 30 or more are inexcusably high. Given moderately adequate resources, a reasonably effective government, and rudimentary transportation, sanitation, and epidemic control, the death rate should not be above 20 per thousand. A birth rate of 40 and a death rate of 20 per thousand mean a rate of increase of 2 per cent, which doubles a population in 35 years.

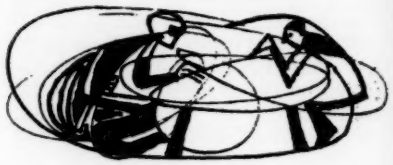
The case is not purely theoretical. In Formosa, under Japanese rule, the death rate of the Chinese population before the war was under 20. In Puerto Rico, where the birth rate is about 40 per thousand, the death rate is about 11 per thousand, giving a rate of increase of nearly 30 per thousand or 3 per cent per year. In the absence of emigration, such a rate of increase would double the population in 23 years. The island already has more than 600 persons per square mile, compared with an average of about 50 in Continental United States. Ceylon, with more than 270 persons per square mile, also has been growing at a rate of nearly 3 per cent yearly. The population of Java probably trebled between 1860 and 1931, by which time its density was more than 800 persons per square mile. The fact is that mankind has become amazingly adept at keeping alive in spite of poverty. As long as birth rates remain at or near 40 per thousand, populations will expand by 2 to 3 per cent per year whenever it proves possible to attain anything like reasonable health conditions. If such populations as those of the Far East do not double their number in 35–70 years, it will mean one or both of two things. Either death rates will be inordinately high, or birth rates will have declined more rapidly than past experience gives us any reason to anticipate.

THE INERTIA OF BIRTH RATES

Let us look briefly at the reasons for expecting the birth rate to be resistant to change. Until very recently, it has been impossible from a technological point of view to achieve low death rates. The populations that could survive to modern times in spite of the inevitably high death rates were those which maintained correspondingly high birth rates. These populations had to have social systems conducive to high

(*Continued on page 128*)

WORLD NEEDS AND RESOURCES



DENNIS A. FITZGERALD

In the following article, Mr. Fitzgerald, Director of the Food and Agriculture Division of the Economic Cooperation Administration, explains the basis for his belief that there are no insuperable obstacles to developing the world's resources rapidly enough to keep abreast of predicted population increases.

PUBLIC discussion, particularly of the last two years, has focused attention on the unhappy economic and social condition of a great majority of the world's population, especially in underdeveloped areas. They are "ill-fed, ill-clothed, and ill-housed." And rearmament has dramatically highlighted the inadequacy of available non-food resources to meet the immediate requirements of the free world. We are "short" of such materials as rubber, tin, manganese, cobalt, aluminum, copper, lead, wool, and cotton.

The Department of Agriculture recently reported that world food production in 1950 was 2 per cent above that of 1949 and probably the largest in history. Yet the number of countries in which average per capita food consumption even begins to approach standards which nutritionists would consider adequate can almost be counted on the fingers of two hands. Canada, the United States, and Argentina in the Americas; Australia and New Zealand, in Oceana; Denmark, Sweden, Switzerland, and perhaps Ireland, Iceland, Finland, and the United Kingdom in Europe comprise the list. The remaining 85 per cent of the world's population exists on diets which range from barely tolerable subsistence to literally slow starvation. Currently the ration of 100 million people in India is nine ounces of grain —about half a loaf of bread—per person per day. This ration together with such limited amounts of nonrationed foods as these people are able to buy provides a caloric intake probably no more than one-half the American level.

In 1946 FAO calculated that, in order to provide a minimum reasonably balanced daily caloric intake of 2,600 calories (the U.S. average is about 3,300) for the prospective world population in 1960, the following percentage increases in food production would be necessary: sugar 12 per cent, cereals 21 per cent, potatoes 27 per cent, fats 34 per cent, meat 46 per cent, pulses 80 per cent, milk 100 per cent, and fruits and vegetables 163 per cent. The achievement of any such increases—averaging nearly 50 per cent—by 1960 is clearly a physical impossibility. Furthermore, it is an economic impossibility, for it would require a roughly corresponding increase in the income of consumers in order to provide them with the necessary resources with which to pay for it.

DEFINITION OF ADEQUATE LIVING STANDARD

We need, therefore, in order to hazard any opinion about the probability of world resources' being sufficient to meet the "needs" of an expanding population, to define what we mean when we use those terms. What are the world's needs for food, clothing, and shelter—usually considered the primary requisites—for education and recreation and medical facilities? That is, what sort of a level of living do we envisage? I doubt that we can establish any objective criteria of measurement, so perhaps the best we can do is to set as the goal a level adequate to promote social and political stability in a free and democratic society. If we accept this definition, "needs" will vary over time and at any one moment will vary greatly from one country to another and even among social groups within a country. A standard of living which today would be considered idealistic by the inhabitants of India or Iran would create revolution in the United States or New Zealand.

One fallacy which it seems to me many of us fall into is to compare the present condition of much of the world's population with that of those at or near the top of the scale and then throw up our hands in despair at the prospect of bridging the gap. If we accept the definition I have suggested, India's or Iran's needs, for example—this year or next year or even ten years from now—are not for an American standard of living, but rather for one which represents a modest albeit real improvement over the immediate past and holds out promise of further gradual improvement in the future. Conceived of in these terms the task looks much less formidable and indeed manageable.

May I refer to one current experiment to illustrate this thesis? When the Marshall Plan began in April 1948, Western Europe was in a precarious position indeed, though its levels of living even then would have been considered sumptuous by hundreds of millions of people in other parts of the world. Social and political unrest was rife, and communism was making rapid inroads. The situation is entirely different today, even though Western Europe's population is now 10 per cent above that of prewar, and per capita income is still only one-third of that of an average American. Social and political stability have been largely restored and communism is losing out. Industrial activity in Marshall Plan countries is now 140 per cent and agricultural production nearly 110 per cent of prewar. And Europe, in general, is reinvesting a sufficient proportion of its current pro-

Address given at Northwestern University Centennial Conference on Science, Technology, and World Resources on March 1, 1951.

duction to afford reasonable prospect that its economic progress can continue without major outside aid. This conclusion is predicated, of course, on the assumption that rearmament—essential as it is—does not require too large a diversion of resources into what is economically unproductive investment.

Moreover, while we usually think of India, China, Japan, and Java as being the areas of the world with the greatest population pressures, the number of people in Marshall Plan countries is by no means inconsequential. The population of the seventeen countries today is in the neighborhood of 275 million. The United States has contributed in the last three years some 12 billion dollars worth of resources to the economic recovery of Western Europe—an amount which represents less than 1.5 per cent of the gross national product of this country. The results of this relatively modest investment in an area containing about one-sixth of the world's population have, it seems to me, been little short of spectacular. And while there are some people who will no doubt disagree with me, I do not believe that this resource contribution by the United States has caused any undue strain on the American economy.

The level of living in most of the Marshall Plan countries still is not good in any objective sense. Average per capita caloric intake at present is only about 2,800 calories—a level slightly below prewar, 15 per cent less than in the United States and only 10 per cent better than in the dark days of 1947. Moreover, the quality of the diet is not nearly as satisfactory as it was in the thirties, or as it is in the United States. It is noticeably better than it was, however, and that is the vitally important point. For people do not require the *ultimate;* they find satisfaction and contentment in progress even though modest progress. Achievement of the ultimate is not "in the cards"—it's like looking for the pot of gold at the end of the rainbow; achievement of steady progress is.

I realize many people will say that we cannot draw any general conclusions from our Marshall Plan experience—that the ratio of population to capital resources in Marshall Plan countries was after all not seriously out of balance and a relatively small contribution quickly tipped the scales. Perhaps the doubting Thomases are right, but I do not believe that this is a foregone conclusion. Indeed, I suggest that there are some reasons for believing that an even smaller relative resource contribution in less developed areas of the world may achieve even more outstanding results.

EFFECTIVE AID TO SOUTHEAST ASIA

As you know, the United States recently expanded its Asiatic program of economic aid to Indochina, Thailand, Burma, and Indonesia. Our purpose there, as in Europe, is to help those new independent countries to create the kind of conditions which will promote political and social stability and the development of free democratic governments. Some social and economic planners have envisaged the necessity of extremely large resource investment in such areas. I am convinced that in agriculture, at least, large-scale investment in underdeveloped areas is unnecessary and impracticable and that if attempted, would in large measure be wasteful. The fallacy lies in attempting to go from a simple economy largely based on agriculture to a modern highly developed complex economy in one step rather than by stages.

In most undeveloped countries, food consumption is very inadequate and yet most of the population is engaged in agriculture. The obvious place to start then—the place to break into what has been called the "vicious circle"—is in agriculture. But let's consider how best to make a start—an example or two may be useful.

Rice yields in most of Southeast Asia are not more than one-third of those of Japan or Taiwan or Korea. There are many reasons for this huge disparity, but the cost of overcoming much of it is relatively small. Dean Ryerson of the University of California at Davis, who is in charge of ECA's agricultural program in Thailand, tells me that rice yields in Thailand can be increased 20 per cent merely by using improved seed varieties. We have one rice breeder in Bangkok now and hope to be able to supplement him with four or five more to work with the Thai authorities in an intensive program of rice selection. In two or three years these scientists can develop and multiply higher yielding strains of rice. We have been assured also that no insuperable difficulty will be encountered in getting farmers to substitute these improved strains for the varieties they now use. Perhaps five years from now, and certainly ten years from now, rice yields in Thailand should be 20 per cent higher than they are now, from this one change alone. Simultaneously, we are helping the Thai scientists determine what kinds of fertilizer and in what amounts can be economically used further to increase rice yields. We know from experience elsewhere that a combination of improved rice varieties and optimum applications of fertilizer will increase yields more than the sum of the increase obtained from each improvement used without the other. The cost of this kind of resource investment is almost negligible in relation either to the returns which can be obtained or to the resources available in the better developed countries.

Let me mention an example in a slightly different field. Most of Southeast Asia's rice is still threshed with a flail or other equally primitive methods. Some time ago, the Japanese developed a simple inexpensive threshing machine operated by "foot power." Modified versions of this machine are now being manufactured by the hundreds in Bangkok, and widespread use of them is just around the corner. Again, resource investment is extremely modest. Economic progress does not require a five-thousand-dollar combine, but a five-dollar pedal-operated threshing machine.

POSSIBLE RATE OF INCREASED OUTPUT

As far as global agricultural production is concerned, I have a deep-seated conviction that output can be increased more or less indefinitely at a rate much larger than any probable rate of population increase. This ignores for the moment the geographical location of these increases in possible contrast to the location of the people who need them. If the demographers are prepared to forecast a population increase at the rate of, say, 1 per cent a year for the next half century, I see no insuperable obstacles to increasing agricultural production at the rate of, say, 2 per cent a year. Moreover, investment to achieve this rate of gain can be made and still leave enough resources available from current production to permit gradual improvement in levels of living.

Let me cite three examples to indicate the possibilities: production per worker in agriculture in the United States today is at least 50 per cent above what it was fifteen years ago. Part of this increased productivity has, it is true, resulted from the substitution of machines for men (and agri-

culture should be "debited" with the labor of the men making the machines), but a major part has been due to the adoption by American farmers of a host of improved ways of doing things developed in the research lab and in the field. These improvements do not require large investments of resources. Scientists in the U.S. Department of Agriculture tell us that the backlog of proven ways of doing things better in the field and in the barn is expanding rather than contracting, that we can look forward to an accelerated rather than a decelerated rate of agricultural productivity.

Again you may object that one cannot generalize from experiences in the United States. But the same phenomenon can be observed in other parts of the world. In Europe, agricultural production has increased at the rate of 5 per cent a year for the last five years. It is granted that part of this increase represented a recovery from war and postwar declines in agricultural production, but certainly not all of it. There is no reason why the upward trend in agricultural output in Europe cannot continue, although perhaps the rate of increase will not be maintained at the high levels of the last five years.

Finally, we might pause for a moment to look at the situation in Taiwan. The Japanese occupied Taiwan from 1895 to 1945. In 1901 the population of the island was between two and one-half and three million, and the output of rice and sugar, its two most important crops, were 438,000 and 30,000 tons, respectively. Its people were illiterate, and if history records the facts correctly, the level of living of its people was little, if any, superior to that of the Chinese mainland. Over the course of 40 years the population of Taiwan doubled, while during the same period rice production almost trebled and sugar production multiplied itself more than 30 times. Taiwan became an important source of food supplies for Japan, and Japanese investment in Taiwan was primarily for that purpose. In the process of its economic development by the Japanese, there was a steady improvement in the level of living of the Taiwanese themselves. Perhaps some lessons can be learned by comparing the course of economic and social development in Taiwan with that of most of the other Southeast Asia colonial territories. They all became large exporters of agricultural products, but only in the case of Taiwan does there appear to have been some degree of balance in other sociological fields. The literacy rate in Taiwan is high—75 per cent—in contrast to an even higher proportion of *illiteracy* in many other Southeast Asia countries.

The above does not imply any higher degree of social consciousness on the part of the Japanese; indeed, the reverse may have been true. But perhaps the Japanese were shrewd enough to recognize that it was in their own self-interest to permit part of the economic gains to accrue to the Taiwanese themselves.

THE PROBLEM OF RESOURCE INEQUITIES

The mere fact that the latent resources of the world in the aggregate are adequate—in my opinion—to provide the world's population with a gradually increasing standard of living does not assure that such will actually happen. The world's resources are very unevenly distributed among the world's population. On a per capita basis some countries are very poorly off in terms of the agricultural—and nonagricultural—resources available to them; others are very well off. Even if it is possible to increase global agricultural production by 2 per cent a year with only modest total investment the location of the increase may not be where the people are. A global 2 per cent may, if nothing is done about it, mean 4 per cent in some countries (and result in the phenomenon of geographical agricultural surpluses) and no increase at all or even a per capita decrease in others.

Selective migration can help some, but it seems unlikely that it can make more than a minor contribution. At least to date migration has been thought of largely in terms of the movement of people to underdeveloped countries; that is, to countries in which the ratio of population to latent resources is low. In this day and age, however, the attitude of people and society to new settlement appears to be different from that of the past. In the eighteenth century, the migrant frequently had no resources other than his hands, with which he "hewed a living out of the wilderness." Today migration of people appears to have to be accompanied by considerable migration of investment resources. One may first be inclined to conclude the old pioneering spirit of the past has disappeared. But the reason for the change is probably more deep-seated. It appears to be true that there is less willingness to accept the very high social cost of old-fashioned resettlement under which the standard of living of the settler for many years is apt to be extremely low. But perhaps a more important consideration is that most of the areas of the world where the latent agricultural resources are "close to the surface" have largely been settled, so agricultural development in the remaining areas of the world requires more than human "capital."

Under these circumstances resources will, in large measure, have to be moved to the areas where populations are located. The difficulty, of course, is that there are many very great inhibitions to the international movement of resources, and these difficulties, at least momentarily, appear to be increasing rather than decreasing. In the "good old days" international transfers were largely the result of the efforts of private capital to find profitable sources of investment, particularly nonagricultural investment. Consideration of the welfare of people in the areas in which the capital was invested was a minor concern or ignored entirely. Today this is no longer the case. Governments are attempting more and more to protect the welfare of their inhabitants, and total investment per unit of output now has to be much greater than in the past. Thus returns from "speculative" investment are much less attractive, particularly when compared to the high rate of return in the last decade or two from capital investment in well-developed countries. Another limiting factor is the attitude of many governments toward foreign control of domestic resources. Limits are placed upon the proportion of an investment which may be in foreign hands in order that majority control may remain in domestic hands. Under these conditions lack of domestic resources in many instances effectively limits total private investment. It seems to me that these and similar limitations to the international movement of resources are likely to be more limiting factors in the nonagricultural than in the agricultural field. If the thesis set forth in the preceding pages is correct as to

the modest volume and specialized character of much of the resource requirements in agriculture, this conclusion necessarily follows.

In the longer run, of course, improvement in human welfare can continue effectively only if there can be balanced development of nonagricultural as well as agricultural resources. In modern society, expanding per capita production both of goods and services in the nonagricultural sectors must proceed more or less proportionately to that of agriculture. Otherwise, the farmer finds himself unable to obtain from the fruits of his labor the goods and services which make it worth while to expand his output. Unless the output of the nonagricultural sector goes up in some rough correspondence to the increased production of farmers, the whole process may grind to a halt. As indicated earlier, I have a deep conviction that for years to come, physically and technically, agricultural production can be increased twice as rapidly as any foreseeable increase in population. The question is whether corresponding advances can be made in nonagricultural sectors and whether economic and social progress result in the slowing down of population increases sufficiently to postpone indefinitely any necessity for the world to hang out a sign reading "standing room only."

By happy coincidence the first need of many hundreds of millions of people throughout the world is for more food. And if my earlier analysis is correct, the investment required to meet this need is relatively small when it is remembered that we are not attempting overnight to reach perfection, but merely to obtain modest increments of improvement. Next to food come clothing and elemental improvements in housing, physical welfare, and education. These latter do not appear to require major investment of resources, although since, in part at least, they have to be provided by society as a whole, they undoubtedly present serious though not insuperable financing difficulties. It is only in the later stages of social and economic progress that resource investment becomes increasingly more important. If we maintain a sense of perspective and avoid attempting to reach the millennium in a matter of years rather than in a matter of decades or even centuries, I am optimistic enough to believe that the world's resources can be developed rapidly enough to meet the needs of a gradually expanding population at steadily improving levels of living.

FOOD RESOURCES AND POPULATION GROWTH

KARL SAX

This article complements the two preceding ones by Frank W. Notestein and Dennis A. Fitzgerald. Dr. Sax is an eminent authority on agriculture and the Director of the Arnold Arboretum of Harvard University, Cambridge, Massachusetts.

TWO-thirds of the world's people do not get enough to eat. Most of them live little above subsistence levels with inadequate food, clothing, or shelter. Most of these people are illiterate, without the skills or knowledge necessary to utilize the great advances in agriculture, industry, and medicine which science has made available to modern man. Yet, as President Truman has pointed out in his Point Four program, "humanity possesses the knowledge and the skill to relieve the suffering of these people." But the President failed to mention the greatest obstacle to world rehabilitation—the population problem. No program to increase food production, promote industry, or improve public health in the underdeveloped areas of the world can be planned on a rational basis without considering the population problem.

At present the world population is expanding at the rate of nearly 1 per cent per year. Every decade, the world must provide food, clothing, and shelter for 200 million more people—a population greater than that of all of North America. The greatest growth, or potential growth, is in the areas of the world which are not now able to provide adequate living standards for present populations.

An efficient agriculture is the foundation of civilization. It not only produces the food needed for vitality and good health, but releases manpower for industry, transportation, construction, and the arts and sciences. Paradoxical as it may seem, the greater the proportion of the working population engaged in agriculture, the poorer are the diets of the people. In China, nearly three-fourths of the population are engaged in agriculture, yet most of the people live at subsistence standards. In the United States, less than 20 per cent of our working population is engaged in agriculture and can produce more food than we need. Yet the Chinese produce more food per acre than we do, although they produce far less per man.

A more efficient agriculture in Western Europe permitted the release of manpower for industry. Industry in turn provided better tools for agriculture, better transportation for food and raw materials, and permitted the exchange of manufactured products for food as populations exceeded local agricultural resources. Urbanization accompanying industry fostered the small family pattern, especially with the abolition of child labor in factories. With the development of farm mechanization and labor saving machinery, large families ceased to be an asset also in agriculture.

The nations of Western Europe, the United States, Canada, Australia, and New Zealand have completed the Demographic Transition[1] from a high birth rate-high death rate culture with low living standards, to a low birth rate-low death rate culture with high living standards. Another 20 per cent of the world's people—largely those of the USSR, the Balkans, Japan, and Argentina—have started the transition, with declining birth rates and death rates. With the notable exception of Japan, most of these countries

Based on an address given at an invitational symposium on world resources at the annual meeting of the American Association for the Advancement of Science, Cleveland, Ohio, on December 28.

[1] Compare with article by F. W. Notestein in this issue.

have the necessary potential resources to provide for the inevitable population growth which accompanies the Demographic Transition. But the transition cannot be made so long as there is war, or threat of war in these areas.

Nearly two-thirds of the world's people still have to begin the Demographic Transition. These peoples live little above subsistence levels, with average per capita incomes less than a tenth of those enjoyed by the people of the modern Western nations.

POSSIBLE ADVANCES IN AGRICULTURE

In general, it should be possible to increase food production in these underdeveloped areas very substantially by introducing modern agricultural techniques. Even in China, where yields per acre are relatively high, greater production with less manpower could be achieved by the use of modern insecticides, fungicides, mineral fertilizers, and equipment. In other areas with less efficient agriculture, yields per acre could be increased even more than in China if economic and social obstacles could be overcome. Let us assume that this 60 per cent of the world's people could double their food production by increasing yields per acre. Such an increase would provide ample calories and a reasonable supply of the protective foods, although far below the dietary standards of the United States. The immediate result would be an increase in population. With better food and the inevitable introduction of public health measures, the death rate would decline. But for several decades at least, the birth rate would remain high, and populations would grow rapidly as they have in Puerto Rico and Mexico during the past decades. It is improbable that even under the most favorable conditions the Demographic Transition could be made with less than a threefold increase in population.

Even with the doubling of the food supply it would require only a few decades of population growth to reduce dietary levels to the original subsistence standards. To provide ample food for the doubled population it would be necessary to increase food production 400 per cent, and if the population tripled before low death rates were balanced by low birth rates, the food production would have to be increased sixfold. Increases of such magnitude are not likely to be attained, even with continued progress in agricultural science. And if populations expanded more than threefold during the transition, we would need even greater miracles in food production.

EXPANSION OF AGRICULTURE IN THE TROPICS

We have not yet considered the possibilities of bringing large areas of new land into cultivation. The world now uses about 2.4 billion acres of crop land or about one acre per person. Most of the world's good farm land with a favorable climate is already in cultivation. Those who see possibilities of a great expansion of new agricultural lands inevitably look to the tropics. Robert M. Salter in *Freedom from Want*[2] proposed that a billion acres of tropical land be brought into cultivation. He estimates that such new land, properly farmed, would yield three times as much per acre as the 2.4 billion acres already in cultivation. Some tropical lands will yield large crops, but in general tropical soils are not fertile and they must be handled with great care if continually cropped. According to Robert L. Pendleton, Professor of Tropical Soils and Agriculture at Johns Hopkins University, "except for relatively very small areas of soils from volcanic ash and recent alluvial soils, most of the soils of the tropics, judged by temperate zone standards, are extremely low in plant nutrient substances and organic matter; nor are most temperate zone methods of fertilization or soil management appropriate." In the tropical rainfall forest areas the removal of the trees exposes the soil to rapid leaching and both mineral nutrients and organic matter are rapidly depleted.

The rapid loss of organic matter and excessive leaching of plant nutrients in most tropical soils is only part of the difficulty in developing an extensive tropical agriculture. As Clarence A. Mills has pointed out, people who live year after year under a blanket of moist heat do not maintain a high degree of physical or mental energy. "Physical and mental characteristics change from the dynamic and pushing to a more passive, let-George-do-it type." The mañana complex is not necessarily an ethnic trait in Latin America.

Perhaps the greatest fallacy of reliance on the tropics for more food for the world is the fact that the greatest food needs must be met in Asia, with half of the world's population. Even in a One World society, the shipment of vast amounts of food from the American and African tropics to Asia imposes serious economic and social problems. Moreover, these tropical areas also have to make their own Demographic Transition with its inevitable and enormous population growth which will absorb much of the postulated increased food supply.

INDUSTRIALIZATION OF AGRICULTURE

Another factor which must be considered in the development of agriculture in the Southern Hemisphere is the prospect of moving workers from agriculture to industry, or of using industrial methods in agriculture. There can be no hope of the Demographic Transition so long as most of the population is engaged in subsistence agriculture. At least half of the working population must be brought into industry or into an industrial type of farming based upon power machinery. The prospects for heavy industry in South America or Africa are remote. Most of the world's coal supply is in the Northern Hemisphere and in the countries already highly industrialized. Without coal, heavy industry must await new developments of power sources. Water power is abundant in both South America and Africa, but much of it is far from the centers of consumption, and hydroelectric power alone will not meet the needs of heavy industry. Only the development of cheap atomic power and methods of converting this power to the needs of heavy industry can enable the development of major industries in these underdeveloped areas.

It should be possible, however, to develop enough industry and other secondary occupations to permit the transition without developing an economy so wasteful of mineral and coal resources as ours. If the per capita world consumption of minerals and fuel were increased to that of the United States, all known and probable petroleum reserves would be exhausted in a decade; the rarer minerals such as tin, copper, and manganese would last for only a few decades, and even the coal would be gone in a thousand years.

An efficient agriculture requires plenty of nonhuman power if it is to be more than subsistence farming, and if it is to release manpower for industry and the arts and sciences. Many of the plans for modernizing agriculture in the tropics, including the ill-fated groundnut project in Africa, envisage huge bulldozers to clear the land, modern tractors to plow and till the soil

[2] Symposium in *Chronica Botanica*, Vol. XI, No. 4.

and trucks to transport the farm produce. Even at the present rate of consumption, and especially if we have to oil another war—hot or cold—the petroleum resources would be so limited in a few decades that farm power expansion would have to look to other sources for liquid fuel.

We shall soon have to look for sources of energy either from atomic power or from the renewable resources of farm and forest. Much more hydroelectric power can be developed, but the total available is not enough. Solar energy can be utilized, and especially in tropical areas, but like hydroelectric energy it has limitations in utilization for heavy industry and for mobile farm power—tractors and trucks.

The renewable resources offer two possible solutions. It is possible to operate tractors with wood-burning generators as was done in Sweden during the recent war. It is also possible to produce alcohol from wood which could be used for liquid fuel. Dr. Egon Glesinger, Chief of the Forest Products Branch of the Food and Agriculture Organization of the United Nations, estimates in his recent book, *The Coming Age of Wood*,[3] that the world's 8 billion acres of forests could yield a ton of wood per acre per year. He believes that such yields would provide not only our needed fuel and power, but also our food. Perhaps so, but economic means of conversion will first have to be developed.

Another possibility is the utilization of algae to produce fats and carbohydrates. Algae can be more productive in converting solar energy to carbohydrates, not because of their greater photosynthetic efficiency, but because they can be grown and maintained in such a manner that they function at maximum efficiency. Grown in shallow vats of water with the proper mineral nutrients, the control of water, temperature, carbon dioxide, and maximum use of solar energy, enables algae such as Chlorella to produce far more carbohydrates per acre than our most efficient crop plants under the most favorable natural conditions. These algae could be used as a primary source of liquid fuel, and could provide carbohydrates for livestock, even if not acceptable for human food. The initial costs would be high, and the problems of maintaining pure cultures of desired genetic strains of algae would be great, but if our renewable resources must provide more and more of our industrial needs, new techniques must be developed on a sound biological and economic basis.

[3] New York: Simon & Schuster, 1949.

AGRICULTURAL PROGRESS VERSUS BIRTH RATE

We can expect continued advances in agriculture, and perhaps new techniques in food production; but unless the birth rates can be reduced in the underdeveloped areas of the world no possible food production can keep pace with population growth at a high living standard. With adequate food and a modest public health program, death rates can be reduced to 15 or less per thousand. Unless birth rates can be reduced below the physiological level of 45 or 50 per thousand, populations would grow at the rate of 2 or 2.5 per cent per year. Even if agriculture and industry could keep pace with such population growth for a few decades, eventually population growth must win.

The facts of population growth can best be understood by considering man's early history. According to the Metropolitan Life Insurance Company, the expectancy of life even as late as the early Bronze and Iron Age in Greece was less than 20 years. Under such conditions a high birth rate was necessary to insure the survival of the human race. Populations grew slowly until the eighteenth century. With the development of modern agriculture, industry, and medicine, death rates declined, and in most of the modern Western nations life expectancies now exceed 60 years. There is no evidence that the natural fecundity of the human species has declined. Thus man has a natural fecundity three times that necessary to maintain a stationary or slowly growing population with modern death rates. If modern death rates could be combined with primitive birth rates, populations would double every 25 years or less.

As an example of potential population growth consider what would happen if Massachusetts could maintain the birth rates of 1800 and death rates of 1950. In one hundred years the population would exceed 2.4 billion, and in less than five hundred years, there would be only standing room on the entire surface of the earth. Yet in Massachusetts we are told that "Birth Control is against God's Law."

Japan provides an excellent example of population pressure on agricultural resources and the difficulties of any rational solution. When Japan opened her doors to Western techniques in 1872, her population was about 30 millions. With the development of agriculture, industry and fishing, Japan prospered. The population grew. Attempts were made to follow the European countries as an industrial power with a colonial empire, but the time was late and the plans too ambitious. Today the Japanese are back on the little islands—84 million of them and increasing by nearly 2 million per year. But the little islands cannot support such numbers at a decent standard of living. When a report on Japan's problems was issued by the occupation forces suggesting that birth rates be reduced, the report was suppressed, due to action by a religious faction of the American occupation personnel.

Dr. Austin Brues, of the Argonne Laboratories, after surveying the results of the atomic bomb explosion at Hiroshima and Nagasaki, and observing the pressure of population in Japan, concluded that population pressure was a far greater threat to world civilization than the atomic bomb. The atomic bomb may never again be used to destroy human life, but the results of population pressure constantly terminate prematurely the lives of millions of people every year. No increase in food production or industrial development can possibly keep pace with a population arising from a primitive birth rate and a modern death rate. There can be no hope for a decent life for all mankind unless birth rates in most of the world are reduced to about a third of the physiological maximum. No plans for increased food production, no world peace movement and no Point Four program can ignore the population problem.

LETTER TO THE EDITOR

DEAR SIR:

In your editorial, "The Mobilization of Scientists" (December 1950), you refer twice to a stand taken by a small number of scientists the world over, once by referring directly to the Society for Social Responsibility in Science, and once indirectly, by speaking of seeking "personal escape" as the explanation of "the refusal to take part in any preparation for war."

It seems to me that you misunderstand, perhaps, the stand of those who founded the Society for Social Responsibility in Science. The stand is clear enough from the preamble of that organization: "Realizing our responsibilities to all of humanity, we, a group of scientists and engineers, in order to direct our efforts and activities more effectively toward a constructive world peace and a humane world, and to stand clearly against any war trend, whether in the United States, Russia, or any other country. . . ." The motivation to subscribe to such a stand is very personal. And therefore the following remarks represent only the writer's views, but not necessarily those of the Society for Social Responsibility in Science.

There are two sources leading to an acceptance of this stand. One is religious; and although—perhaps not so surprisingly—the word "God" has found its way repeatedly into the *Bulletin*, this source does not belong here, and is beyond argumentation. The other source is purely logical, and may be submitted for critical review. Accepting war research implies obviously the acceptance—at least as ultima ratio—of war. It is probably no exaggeration to say that all readers of the *Bulletin* are opposed to the results of war. But the majority consider them as "the lesser of two evils," capable of bringing ultimately a good result (e.g., freedom). Now, I submit, that this reasoning is based on the denial of cause and effect in social behavior and in history. And I claim that history seems to prove that there is an unalterable sequence in cause and effect in social behavior; so much so, that one might offer a hypothesis that there is an absolute law governing these consequences, of the same kind as natural law, which we consider as unalterable by definition.

If such law exists, then the concept that the desirable end (freedom) can be obtained by undesirable means (war) is wrong, and the undesirable result would *inevitably* follow from undesirable means. We would only burden successive generations with a heritage, not only of destruction and debt, but also of having to solve the problems which we aggravated by resorting to the wrong means.

At this point one might argue that this reasoning may be correct or incorrect, but that as loyal citizens of a democracy we have to accept the decision of the majority. . . .

However, if such absolute laws of cause and effect in human behavior exist, then the majority can no more decide to abrogate them than it could decide to abrogate the law of gravity. Moreover, by the Nuremberg trials this country has confirmed that the individual must refuse cooperation with what he considers wrong—even with stated laws of government and society.

In a very humble and ineffective way I want to try to give the rest of my life to an exploration of the above hypothesis of the absolute validity of cause and effect laws in human and social behavior, and I can do so only by accepting it as valid until it is proved incorrect—a proof which would be conclusive only after a long time—a time longer than the span of human life.

I feel that the reproach of personal escape is not quite fair. I submit that the person who with uneasy conscience continues to do work of which he is not quite convinced but which is in agreement with the majority is practicing much more "escape" than the person who ventures to try to live his idea even if it be extremely unpopular and who thereby risks his job, his income, and his material security.

VICTOR PASCHKIS

President
Society for Social Responsibility in Science

BOOKS RECEIVED

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Atoms at Work. By GEORGE P. BISCHOF. New York: Harcourt, Brace, and Company, 1951. Pp. 130. $2.25.

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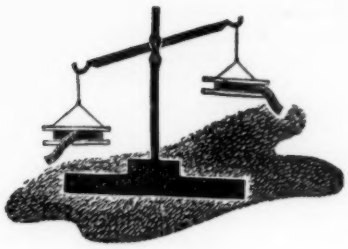
REACTOR PROGRAM OF THE ATOMIC ENERGY COMMISSION



LAWRENCE R. HAFSTAD

The Director of the Division of Reactor Development of the Atomic Energy Commission outlines the technical and economic factors which will determine the feasibility of using atomic energy as a source of power and gives special attention to the potentialities of the envisioned multi-purpose reactor.

THERE are few subjects about which there has been more talk and less said than that of atomic power. Interest in the subject, for various reasons, seems to be so high that a few available bits and pieces of information get chewed over again and again as part of an effort to get public understanding of the subject. For various reasons, also, the emotional content of most presentations runs high, and this adds little to that clarification of issues which is to be desired.

I will try my best to give you a status report as to where we are now, will try to call your attention to trends which seem to me to be of significance and worth watching, and finally, to suggest the problems and issues which are emerging and will require attention at some future time.

We can classify most of our problems at the present time in two main categories, namely, technical and economic. These I will discuss in turn.

SCOPE OF THE TECHNICAL PROGRAM

To date we have been almost exclusively preoccupied with problems in this category. You will recall that nuclear reactors are the machines for converting the energy available from the chain reaction into useful forms. Most dramatically, perhaps, the reactor is a slowed down and controlled atom bomb explosion. The technical problems involved are many and have frequently been described. For example, there are the problems of:

1. Materials to stand higher temperatures than are attainable from chemical reactions.

2. Materials which show minimum radiation damage under the intense bombardment of neutrons, gamma-rays, etc., in the interior of the reactor.

3. Materials which do not absorb and waste an excessive proportion of the available neutrons.

4. Shielding of personnel and instruments against the adverse effects of radiation.

5. Control gear with response times adequate for safety.

6. Heat transfer rates higher by an order of magnitude than those conventionally used.

7. The control of radioactive materials produced in the fission process and deposited with the fuel elements to the detriment of the neutron economy.

8. The handling and ultimate disposal of radioactive wastes in a manner which will constitute the minimum health hazard.

The difficulties involved in these problems have often been stressed and I will not belabor them further. The important point, however, is that it is with precisely these problems that our huge national laboratories have been preoccupied since 1945. Much progress has been made toward solution but, as in other applied research programs, just how much is difficult to assess without some full-scale trials.

This brings us to the second major phase of the current reactor program and that is the specific reactor projects.

Address delivered on November 15, 1950, before the American Petroleum Institute at Los Angeles, California.

These, too, have been previously described in considerable detail but, you will recall, are four in number.

1. *A Materials Testing Reactor,* designed for the highest neutron flux yet attempted. As its name indicates, it will be used in the development of other reactors. Construction is well advanced.

2. *A Ship Propulsion Reactor,* which is to be a land-based prototype of a reactor for propelling submarines, is being designed to operate in the slow neutron energy range with which we have had extensive experience. Construction is well under way.

3. *An Experimental Breeder Reactor,* designed primarily to explore the possibilities of breeding, that is, producing more fissionable material than is consumed. This reactor will operate in the high energy or fast neutron energy range. We have one other reactor operating in this range. Construction and fabrication is practically complete and installation is beginning.

4. *A Ship Propulsion Reactor* designed to operate in the intermediate neutron energy range, in which we have had no experience. This project, basically a power reactor, replaces an earlier project for an intermediate reactor for both power and breeding. This project is now in advanced stages of engineering design.

PRESENT STATE OF PROGRESS

Most of these reactors were officially authorized for construction now nearly two years ago and several of them, we note, are well along the road toward completion. Progress on these reactors has a significance far beyond the con-

tributions of the individual reactors themselves. Such progress gives us for the first time since 1942 an objective measure of the "state of the art" in reactor technology. In general, progress has been slightly but not seriously behind schedule. My stock answer to queries in this regard is that the program is progressing slightly better than I expected but not as well as I had hoped. I'm sure some of you gentlemen can well appreciate the feeling behind that statement.

As technical people, however, the important thing to us is that I can report that the delays were not due to unforeseen and unexpected technical troubles. Our worst bottleneck, for example, has been the production in pure form and in ton quantities for structural purposes of a chemical element which, until a year ago, was essentially one of the curiosities lumped under the rare earths in the periodic table. To a technical man, a bottleneck of this kind isn't even interesting, it's only a damned nuisance. Other delays have been due to procurement difficulties in the case of essentially conventional items such as tanks, valves, pumps, etc. I fear that it is almost an occupational disease on the part of a scientist to focus attention on the part of a problem of particular interest to him and neglect what appears to him to be prosaic. I recall with some embarrassment, for example, my own experience during the early part of the last war, when we were successful in producing, in quantity, radio parts which could stand being fired out of cannon, but then absorbed a long delay while we tooled up, to machine in quantity, simple parts of ordinary steel.

In summary then, so far as specific reactor projects are concerned, our laboratories seem to have done an adequate job of applied research, and to have provided our designers with adequate "handbook" type of data. Our designers in turn seem to have successfully avoided gross troubles of the type which might be uncovered early in a construction program. For a final and more detailed answer, we must wait until the present generation of reactors has been carried through the debugging stage and is in actual operation. We are, so to speak, on a "construction plateau" in our program, our bets are made, our resources committed. We can only await as philosophically as we can the final result.

FUTURE REACTOR NEEDS

So far we have been discussing technical problems in the current crop, the present generation of reactors. While we are stalled on the aforementioned construction plateau, it is not too surprising that there should be considerable discussion as to what types the next generation of reactors should include. Remember—reactors are expensive. Small ones cost from $1 million to $5 million; full grown ones $25 million to $50 million. Reactor designs are numerous. What with breeders and non-breeders; high, low, and intermediate neutron energy; high, low, and medium temperatures; natural, slightly enriched, and highly enriched fuels; homogeneous and heterogeneous fuel distributions; assorted moderators, coolants, and corrosion resisting coatings, the number of permutations and combinations runs high. The problem is not to invent a reactor. The problem is to select one which will yield maximum returns. But what, really and honestly, are our reactor *needs*? Before we can evaluate a promise to fill a need, we must be agreed on the need itself.

First, let us clear the air of some unnecessary confusion. Various articles state or imply that there is a great and immediate possibility of use for civilian atomic power which is being sabotaged by (*a*) the military, and (*b*) the private power interests. A Russian physicist, writing in the Moscow *Literary Gazette*, recently quoted in the *Daily Worker*, for example, claims that Americans "sabotage the peaceful use of atomic energy because it would outdate old machines and make coal and oil valueless." If such statements contain even one iota of truth, then in my present position as Director of Reactor Development, I would expect to be a focal point for such pressures, but I can only report that in nearly two years they have failed to develop either from above or below. I can go further, since this is a free country, and urge these pressure groups to hurry to make their influence felt, lest decisions be made in the next few weeks without their help and contrary to their interest so that all their effort and work might be wasted! This would indeed be a shame!

In the meantime, let us return to our technical problem, namely, that of picking, in the national interest, the most promising reactor or groups of reactors. We *need* production reactors for producing fissionable material for either military or civilian use. We can probably *use to advantage* mobile power reactors if the cost in both dollars and fissionable material does not prove to be prohibitive. We can *justify* heavy commitments to reactors producing electric power only if and when the cost of this power bears a reasonable relationship to the cost under comparable conditions of power available from conventional fuels. These are the boundary conditions on our problem.

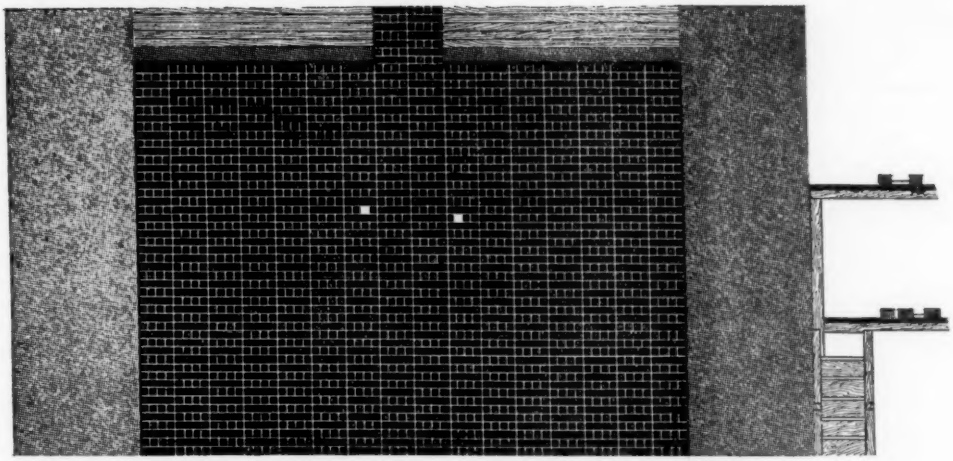
Now, which reactors should be built? To justify building an expensive reactor, we must, or should have, a *demonstrable need*. To assess the need we must know costs, but costs can only be determined by first building the reactors. This is the circular argument in which we continually find ourselves. To break out of this vicious circle we have used the fact that, for the military needs, the unknown economic factor is less compelling.

We can draw a few other general conclusions from our reactor experience to date. For example, with fissionable material in great demand for bombs, we must concentrate on power reactors which, at least partially, replenish or replace fissionable material used up. Mobile military reactors therefore converge on production reactors, and both should eventually be combined with breeding of new fuel, that is, the breeder reactor, which continues highly desirable. Furthermore, the civilian power reactors, precisely because of their need for the lowest possible cost of power produced, are tending to interlock with production processes and therefore with the production reactors for military uses. Thus, instead of being separable into neat little problems which can be solved, one at a time by themselves, the trend appears to be toward greater complexity with a pronounced interlock between production, mobile, and civilian power reactors.

Note how insistently the economic factor intrudes itself into what we would like to consider as a purely technical problem. Let us therefore turn to the economic problem before trying to summarize the desiderata for the next generation of reactors.

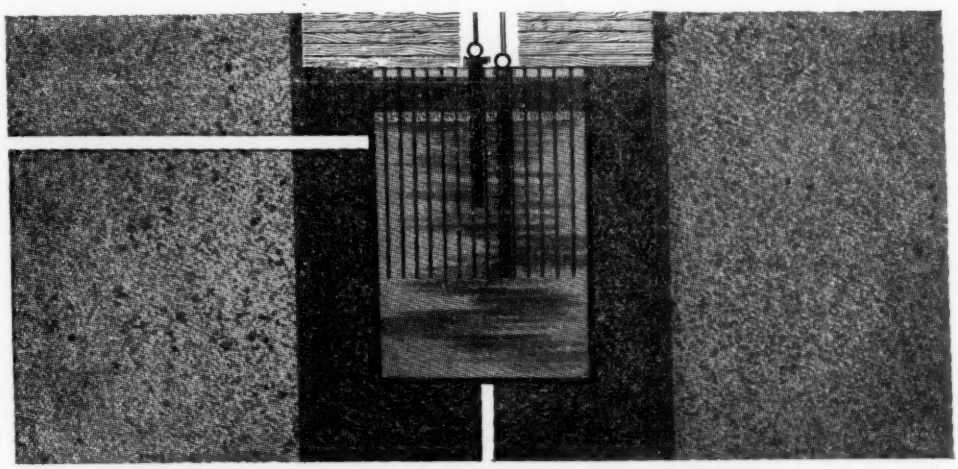
IMPORTANCE OF THE ECONOMIC FACTOR

Critics of the American atomic energy program invariably make the assumption that civilian atomic power could be made practical (i.e., cheap) and generally available if only those in authority had the will to do it. The assumption is that by another billion dollar crash program, of the Manhattan District type, the remaining necessary "secrets" could be uncovered and the real atomic era ushered in. Actual-



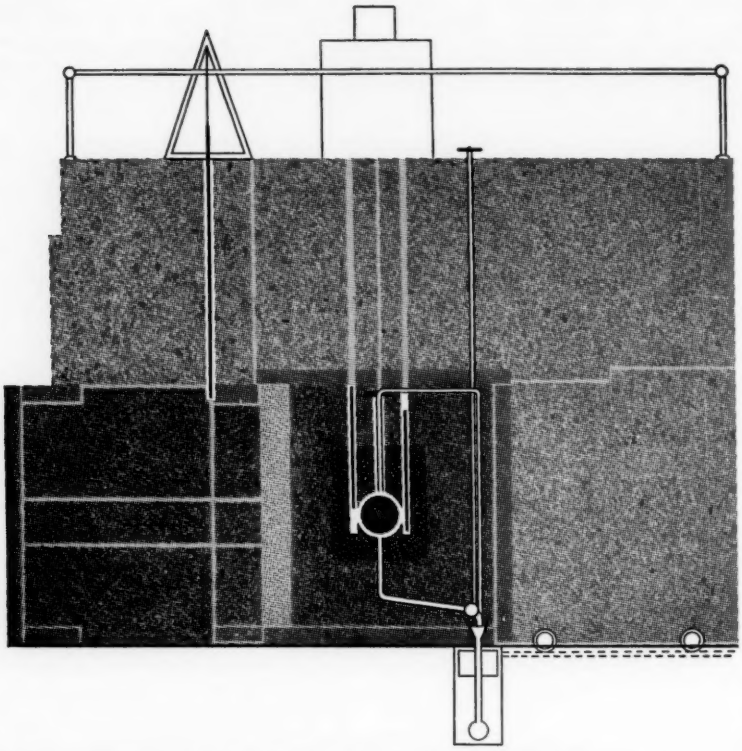
NATURAL URANIUM-GRAPHITE REACTOR in which the first self-sustaining nuclear chain reaction was achieved is shown in this simplified cross section. The reactor was originally built at the University of Chicago and later rebuilt at Argonne National Laboratory. It is basically a large cube of graphite blocks, some of which contain small cylinders of uranium or uranium oxide. An outer layer of graphite blocks containing no uranium serves as a neutron reflector. The shaft of blocks sticking up from the top of the main cube in the cross section is the "thermal column," a means by which slow neutrons may be permitted to diffuse out of the reactor for experimental purposes. The wooden structure at the right supports control rods and stringers that may be inserted into the cube; the holes in the front of the cube permit the insertion of safety rods. The uranium cylinders are not shown.

CONCRETE
GRAPHITE
LEAD
WOOD



HEAVY-WATER REACTOR at Argonne National Laboratory is shown in a simplified cross section based on written descriptions released by the Atomic Energy Commission. In this reactor the neutrons produced by fission are moderated by heavy water instead of graphite. The heavy water is contained in an aluminum tank approximately six feet across and nine feet high. Suspended in the tank are 120 uranium rods. Around the tank is a layer of graphite to reflect escaping neutrons. Around the graphite is a layer of lead-cadmium alloy and a heavy shield of concrete. At the top of the tank is a layer of lead; beneath it is a thin layer of cadmium, and between the cadmium and the heavy water is a layer of helium. Toward the right side of the tank is a control rod. In the middle of the tank is the "experimental thimble," a device for inserting experimental materials into the reactor. Above the tank is a layer of wood and steel. The heat generated by the reactor must be dissipated; this is accomplished by circulating the heavy water through a heat exchanger (*pipes at left and bottom*). Among the details not shown by this cross section are two horizontal columns of graphite that pass through the concrete shielding. One of these is to insert experimental materials into the reactor; the other, to permit a beam of slow neutrons to pass out of it. The reactor can handle 32 neutron irradiations simultaneously.

CONCRETE
GRAPHITE
LEAD
HEAVY WATER
WOOD
HELIUM



HOMOGENEOUS REACTOR, or "water boiler," at Los Alamos Scientific Laboratory combines fissionable material and moderator in one solution: a uranium salt dissolved in heavy water. The solution is contained in a one-foot steel sphere near the center of this simplified cross section. Around the sphere is a neutron reflector made up of a layer of beryllium oxide and a layer of graphite. Inserted in the beryllium oxide to the left and right of the sphere are the reactor's control rods. Within the sphere is a coil of pipe (*see photograph on opposite page*) through which water is circulated to cool the reactor. At the lower left in the cross section is a tunnel of graphite for experiments requiring exposure of materials to slow neutrons. For experiments requiring exposures to a high flux of fast neutrons materials can be inserted through the "Glory Hole" into the heart of the reactor. Hanging through the concrete shielding at the upper left is a cadmium curtain that can be dropped across the graphite tunnel. At the lower right is a concrete door that can be rolled out to permit access to the reactor. The homogeneous reactor was first built as a low-power apparatus without shielding; it was called **LOPO.** Later its power was stepped up and shielding was installed; it was then called HYPO. A reactor of this type is expected to be built by the Consolidated University of North Carolina for North Carolina State College.

ly, there seems to be little in common between the atom bomb problem and the civilian power program except the language. They differ in kind rather than in degree. The atom bomb problem was almost uniquely a "black and white" problem. It was either a grand success or a colossal failure.

The civilian power problem is quite different. Enough technical facts have long been known to assure us that electric power can be produced if we are willing to pay the price. It is for this reason that the crash program approach is the last thing we want in the civilian power problem. If correct bookkeeping procedures were followed, the high costs of such a program would have to be charged to the power ultimately produced, thus *raising* rather than lowering its cost. In many respects, the economic factor makes the civilian power problem a tougher one than the atom bomb problem and we will have to look elsewhere for an analogy. Perhaps the closest we can come is the problem of private flying for the airplane industry. Here, as in the case of civilian atomic power, the technical problems are already essentially solved at least to a first approximation. Until private flying becomes much cheaper, willing potential customers, like myself, for example, will continue to look upon private planes as an unjustifiable luxury. At the moment, civilian atomic power is similarly potentially available, but only as a luxury civilians can't afford.

Figures in the literature on estimated costs for atomic energy vary by at least a factor of ten. I am not going to try, at this time, to give you more accurate cost figures for three very good reasons.

1. They do not exist even within the Atomic Energy Commission.

2. If they did exist, they could not be released for security reasons.

3. If they did exist and if they could be released, I wouldn't believe them anyway.

My pessimism in this matter stems from the fact that two variables are involved both of which are uncertain. As in other human activities, we must consider both the initial cost and the upkeep. The first factor is still essentially unknown for we have never even designed, much less built and operated, a reactor intended to deliver significant amounts of power economically. The second factor is even more uncertain since all fissionable material to date has been produced in a government monopoly on a crash program basis in such a way that precise cost allocation to any one item simply cannot be made.

The only really significant figure for the cost of civilian power from atomic energy would be one based on a power system which pays its own way with only civilian instead of military uses of by-products, all the way from the uranium mines to the waste disposal jump.

WHERE COSTS CAN BE REDUCED

Even excepting the additional complications introduced by the security problem the situation in regard to cost estimates is quite unsatisfactory, both inside the commission and in the open literature. The hearings of the Appropriations Committee are vivid testimony to the effect that in this business estimates cannot be taken at face value and invariably turn out to be too low. It is for this reason that my own approach has been to set upper limits on cost based on the firmest available costs on the most nearly similar reactor either built or under construction. We cannot take too seriously estimates based on the cost of low temperature production reactors and the assumption that they can be redesigned for higher temperature operation. If this were easy to do it would have been done in the first place and, if it is not easy to do it is likely to be expensive. Thus I have been driven back to the Ship Propulsion Reactor

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as our currently best available yardstick for nuclear power costs. A rough figure for this has been given as $1,400 per kwh. installed capacity for nuclear power, as against $133 for the corresponding equipment of a conventional power plant.

Now we know that while in a mature and highly competitive business such as the power industry, it will be slow work to reduce further the $133 figure, there are many savings which can be made in the $1,400 figure for the mobile nuclear power plant. Let me list some of the high cost items where savings seem possible:

1. High development costs of a prototype reactor.
2. High costs for meeting naval requirements of weight and space.
3. High cost of reprocessing fuels.
4. Lack of volume production.
5. High costs introduced by extreme security precautions.
6. High costs introduced by extreme personnel safety precautions.

If with savings in these items, and the almost certain technical improvement in a field as new as atomic energy we can pick up a factor of two or three we are beginning to close in on the competitive figure of $133 for corresponding capital costs in the conventional installation.

To effect these savings, it has been my personal opinion that fastest progress would be made if we could move toward the design and construction of reactors on a competitive bid, fixed price basis, or by otherwise utilizing a profit making incentive. As in other major projects, this would require carefully written specifications covering, however, the hazard problem and the security problem in addition to the more conventional provisions. This will not be easy, but I believe that ultimately it can be done if we in Washington have both the will and the ingenuity.

Turning to the fuel cost problem we can only emphasize that even for nuclear fuels this item is not negligible. Taking from the open literature the figure of $20 per gram for nuclear fuel as a basis, we still get a fuel cost of one mill per kwh., as compared to two mills for chemical fuels. The $20 figure is almost certainly low and seems likely to increase as the supply of high-grade uranium ore runs out. For single-purpose civilian power-producing reactors burning U-235, the conclusion remains, then, that for nuclear power the cost of fuel will be about the same as for conventional plants, while the cost of the installation (and probably its operation) will be considerably higher. Exactly what the cost figures will be cannot be known until we find it possible to try the experiment.

There has been a noticeable increase in recent weeks in articles in the popular press on the imminence of industrial participation in the atomic power field. By implication, it might be assumed that some major technical advance has been made, some new "secret" discovered which at long last will make civilian atomic power available in quantity. From my remarks on the technical factors involved, it should be clear that there are no new elements in the technical picture which have suddenly made the possibility of civilian power more attractive and we must look elsewhere for the reasons underlying the greater interest in industrial participation both on the part of industry and the AEC.

ECONOMY OF MULTIPLE-PURPOSE REACTORS

So far I have talked mostly about reactors whose sole reason for existence was the production of power. But we have reactors producing plutonium which throw away their heat. Suppose this heat could be put to some useful purpose, say the production of power, or even the distillation of sea water? What then is the economic picture?

Here cost estimates are only rough at present. But one thing is certain: utilization of by-products can sometimes salvage a proposition originally not economically feasible. Now technically a reactor to produce both power and plutonium is not out of the realm of possibilities. We don't know much about such a reactor yet. But if we can make one work, the value of the plutonium would allow us to charge off much of the operating cost to the production of the plutonium, and might provide the power at reasonable costs.

Progress in the atomic energy field has brought us to a point where we can see more clearly the real nature of the joint government-industry effort that is required to realize the potential in atomic energy. In some respects, it is clear to us only in terms of problems to be solved. But those problems have been identified sufficiently for both the commission and industry to determine the most effective role each must play.

The level has been substantially raised in our reservoir of technical knowledge. We have more tools with which to work, but our work load has increased even more. In the meantime, industry has expanded its competence in the field of atomic energy and begins to see its own role in terms of something other than job contracts. It is the multiple-purpose reactor which holds the greatest promise of returns, both for the government and for industry, and promise of the real benefits of atomic energy about which we have all been so hopeful.

The commission, on its own part, must explore further procedures which will induce industry to carry heavier responsibilities in this field, which is the beginning of a new phase of the commission's approach to its problems.

I think I can say with some confidence that it is this element rather than a new imminence of cheap civilian power which lies behind the increased interest on the part of industry in certain phases of the atomic energy business. It follows as a corollary that while in the immediate future there may be some maneuvering for position—that is, getting better prepared for active participation—on the part of various organizations, the predicted "cut-throat competition" and the show-down battle between the public and private power interests can still be regarded as being some distance in the future.

Suppose now that either out of its own laboratories or from industrial contractors we do get a design of a reactor producing plutonium and yielding electric power as a by-product. Does this finally usher in the atomic era? I'm afraid not. The major charges will still be carried by the military need for plutonium. Only if and when we can produce fissionable material which, when used for civilian power, will pay for its own production costs, can we truly say that the civilian atomic power problem has been solved. In the meantime we would be less than prudent if we did not take advantage of every opportunity to reduce over-all costs by an increasing emphasis on the use of by-products, as has in the past been so successfully done by industry.

IMPEDIMENTS TO INDUSTRIAL PARTICIPATION

Assuming then that it is desirable to have greater industrial participation, and by this let us agree to mean responsible, cost-reducing, competitive participation, what are the problems which arise?

First and foremost there will be the problem of shortage of personnel. A recent IBM card run on our national scientific roster turned up a total of

only 350 names in the whole country of people who list themselves either as mathematical physicists or as nuclear physicists. Of these, most will be engaged in university teaching, others will be suspect "intellectual pinks," so it is not surprising that we count our experienced reactor designers almost on our fingers. Essentially all the remainder are already committed and overcommitted by our present program, and nothing would cause more disruption in this program than an irresponsible uncontrolled proselyting of key personnel. This is a primary problem. Its solution will almost certainly lie in a training program on an expanded scale for our embryonic industry.

A second very serious problem will be that of unpredictable costs which may be introduced at any time during operation by government decree. These will be mainly in the fields of security, fissionable material accountability, and personnel safety both in and near the plant. In this field, initial agreements can probably be worked out, but abrupt and arbitrary changes in the rules of the game after the play is under way are going to raise interesting questions.

A third category of problems which can readily be foreseen is that toward which the industrial "market survey" is aimed. In other words, what is the future market for your product? As is well known, the government is reluctant to commit itself in advance for expenditures in future years. Yet in a development as ponderous as that of atomic energy, any privately financed industrial approach would have to be based on firm plans for five, ten, or more years in the future.

Another knotty problem is that of the fair and equitable distribution among many interested parties of the opportunity to play an active part in this field. In this regard, I recall the early days of radio when lawyers argued furiously that each citizen or group of citizens had a constitutional right to an equal share of the radio-frequency spectrum. The fact that the extent of the available spectrum was limited by natural law somehow did not seem to register.

Finally, there is the category of legal problems which can usually be solved with congressional action if necessary. In this case there are additional complications due to international implications in our United Nations' position involving an inspection system.

It is clear that problems are many and, viewed philosophically, it might well be said that we are currently engaged in trying to develop an atomic energy industry with none of the advantages of either the American or the Russian economic system.

THE LEADING CANDIDATES

Now, let us return to the intriguing problem of picking the leading candidates for the next generation of reactors. We need reactors—more accurately, there is an expressed demand today for reactors—for the following purposes:

1. As a research tool, both by universities and by industry.
2. For mobile power, almost exclusively military.
3. For the production of fissionable material.
4. For the generation of power.

The first of these presents few problems since they can be, in general, small, safe, and relatively inexpensive.

The second and third and fourth categories are already large, complex, and expensive, and for reasons given above, promise to remain so. And their development problems are inexorably interlocked. In order that advances in design in these enterprises can be made at lesser risk, we have found it necessary to establish still another category of reactors. This is really an interim class for developmental purposes, namely, the experimental test-prototype reactors.

These are reactors which will permit us to separate the variables inherent in the large multi-purpose reactors. The EBR (Experimental Breeder Reactor), for example, is one of these. As its name implies, it will enable the breeding problem to be studied essentially by itself with a minimum of interference from the demands of, let us say, high temperature, efficient production, or maximum power. A similar reactor which will permit us to test our knowledge, predictions, and techniques in connection with the homogeneous reactor approach has been authorized. Still another experimental reactor designed for the highest temperatures which could conceivably be obtained with "soon to become available" materials is on the drawing boards.

Beyond these a confusing array of still other reactors are being "talked about." The problem is, and will continue to be, to select and focus major effort on those projects which promise the greatest long-range returns.

Summarizing then, and focusing our attention on trends, we note that discussion and interest has shifted from the question of whether power reactors can be built to which should be built and which will prove most economical. This represents real technical progress. Current efforts are proceeding on two fronts, a direct attack on those problems confronting reactors for which there is a present real demand, production and mobile reactors, and a parallel attack on the applied research front, looking toward proved technological advances which at some future date can be safely incorporated in the main line of large reactors. We note a trend toward complex multi-purpose reactors with civilian power probably emerging first as a by-product from production reactors and perhaps ultimately in its own right. Finally, we note an increasing interest on the part of the commission to consider proposals for industrial participation.

All in all, though the road ahead is still long, I believe it would be safe for me to paraphrase the famous remark of General Collins on Korea, and say that "the beachhead [of interest in civilian atomic power] has been as small as it is ever going to get."

THE CHRISTIAN CONSCIENCE AND WEAPONS OF MASS DESTRUCTION

Report of a Commission appointed by the Federal Council of the Churches of Christ in America

Sixteen protestant theologians and laymen attempt to define the circumstances under which the use of atomic weapons could be condoned and to outline steps which might be taken to preclude the necessity for their use. Two other members of the commission submitted a minority report, which proposed that atomic weapons be outlawed. The condensation of the majority report, presented below, is essentially that released by the National Council of the Churches of Christ in the United States of America, an affiliate of the Federal Council.

WHEN we look out upon our world we see an ugly and unclean thing hanging over all the brightness and the good and even the shared sorrows and shared failures that make precious our human existence. It is not Christians alone or Americans alone who see this darkness or whose lives and homes and children and cities and laboriously built structure of common life are threatened by it. It is mankind that lives under this cloud. We Americans think in dread of what could happen tomorrow or five years from now to Chicago or New York or Washington. Frenchmen think of what could happen to Paris; Englishmen of what could happen to London; Russians of what could happen to Moscow.

This ugly thing, which we call war, hanging over our common humanity, is not something new. Through all man's tragic history he has suffered locally and periodically from war. But the dimensions of the evil in any major conflict are now so heightened as to face us with something new.

It is as though the One who said to us, "They that take the sword shall perish by the sword," were pointing with inexorable logic to a Dead End toward which man's way of violence leads. Each stepping up of the powers of violence calls out more demonic ingenuity in matching destructive power with destructive power. Resistance to the use of more brutal weapons is broken through in a struggle for existence that at last threatens all existence. The means we have found of blowing up whole cities reveal mankind as in an inescapable community of danger and fear. The only real escape from these evils of war is the prevention of war.

Even in the face of that judgment we have to recognize that the overwhelming majority of Christians have held that there are times when Christians should take the sword and fight as very imperfect servants of God's justice. They have fought for what they believed was justice or good order or freedom, and against wanton aggression or enslavement.

Faced with the terrible ambiguities and compromises of fighting to serve even in so crude and soiled a way the more elementary demands of God's justice, sensitive Christians have sought to bring war itself under some restraints. In this they have certainly been joined by other men of good will. They have struggled to reduce or eliminate the savagery and sheer sadism that are set free by the madness of war. They have condemned the killing of prisoners and of hostages or the use of torture to gain military information. They have condemned the massacre of civilian populations, especially of women and children and the bombardment of "undefended" towns. They have sought to bring the radical lawlessness of war under some law.

Plainly what we now face in war and the threat of war and our involvement in it is an overwhelming breakthrough in the weak moral defenses erected to keep war in some bounds. At no point is this break-through more evident than in the widespread acceptance of the bombing of cities as an inescapable part of modern war. The industrial and technical potential of strong nations is now concentrated in cities. Their factories and power plants and fuel stores and transportation centers are their arsenals of war. It is forcefully argued that to destroy or cripple them by tons of "conventional" bombs or by raining fire upon them or by one atomic bomb is to strike at their fighting power as surely as to destroy an army or a fleet or an air force. In the harsh light of history, the best hope of preventing a global atomic war lies in preventing the recurrence of global war itself.

It is in this time and situation that we who profess and call ourselves Christians must make our decisions.

WAR AND WEAPONS OF MASS DESTRUCTION

The clearest and least ambiguous alternative is that urged upon us by our most uncompromising pacifist fellow-Christians. For them the infinitely heightened destructiveness and the "amoral" character of modern war confirm their conviction that followers of Christ can make no compromise with so great an evil. They find them-

selves called to follow the way of love and reconciliation at whatever cost and to accept the historical consequences of a repudiation of armaments and of war. For those who make this radical decision, the need for debate as to the choice of weapons is ruled out by a repudiation of all weapons.

Pacifist and nonpacifist Christians can probably agree that, as men are, responsible political leaders could not take the pacifist position and continue to hold positions of effective political leadership.

The large majority of professing Christians are not pacifists. But Christian nonpacifists agree that in all human conflicts the most righteous side is never so righteous as it thinks it is. They acknowledge that whatever good may ever come out of war, incalculable evil always comes out of it, too. We believe that God calls some men to take the way of nonviolence as a special and high vocation in order to give a clearer witness to the way of love.

But most of us find ourselves called to follow a course which is less simple and which appears to us more responsible because more directly relevant to the hard realities of our situation.

Most Christians, faced with the lawlessness of our world of nations, see no way of serving the righteousness of God in the presence of brutal and irresponsible violence save by taking responsible collective action against aggression within the framework of the United Nations. In the last resort we are in conscience bound to turn to force in defense of justice even though we know that the destruction of human life is evil. There are times when this can be the lesser of two evils, forced upon us by our common human failure to achieve a better relationship.

Today, two great dangers threaten mankind, the danger that totalitarian tyranny may be extended over the world and the danger of global war. Many of us believe that the policies most likely to avoid both dangers inevitably carry the risk of war.

CONCEPTS OF TOTAL WAR

War has developed rapidly in the direction of "total war" in two meanings, which it is important to distinguish.

In the first meaning, total war refers to the fact that in a conflict between highly industrialized nations all human and material resources are mobilized for war purposes. The traditional distinction between combatants and noncombatants is far less clear. Only small children and the helpless sick and aged stand outside the war effort. It is practically impossible to distinguish between guilty and innocent. Total war, in this sense of the involvement of the whole nation in it, cannot be avoided if we have a major war at all.

Total war, in the second sense, means war in which all moral restraints are thrown aside and all the purposes of the community are fully controlled by sheer military expediency.

Christians and Christian churches can never consent to total war in the second sense. The only possible justification for war is that it offers a possibility of achieving a moral result, however imperfect, to prevent an overwhelming moral evil.

Humane men of any faith, if they find themselves driven to hurt, will hurt as little and as few as possible; and if they find themselves driven to kill, will seek to restrict killing within the harsh necessities determined by their total goals, military, political, and moral. Military victory is not an end in itself. Just as death is preferable to life under some conditions, so, too, victory at any price is not worth having. If this price is for us to become utterly brutal, victory becomes a moral defeat. Victory is worth having only if it leaves us with enough reserves of decency, justice, and mercy to build a better world and only if it leaves those we have conquered in a condition in which they can ultimately cooperate in the task of setting forward God's purpose in creation. Hence the way we fight and the means we use are of crucial importance. And these will be determined by the spirit in which we fight and the purposes for which we fight. Military expediency, therefore, cannot be the sole test, but must be subordinated to moral and political considerations.

THE WEAPONS OF MASS DESTRUCTION

Can we find some absolute line we can draw? Can we say that Christians can approve of using swords and spears, but not guns; conventional bombs or jellied fire, but not atomic bombs; uranium bombs, but not hydrogen bombs?

We find no "clean" methods of fighting, but some methods are dirtier than others. Some cause more pain and maiming without commensurate military decisiveness. Some are more indiscriminate.

Sin in its inward meaning cannot be measured by the number of people who are affected. But a reckoning of consequences is also a part of a Christian's decision. It is more dreadful to kill a thousand men than one man, even if both are done in the service of justice and order.

Here a distinction can be drawn between precision weapons, which can be directed with reasonable control at primary military objectives, and weapons of mass destruction. But we are compelled to recognize that the increasing distance from which bombs or projectiles are released and the speed of planes and guided missiles are likely to offset all gains in precision. If, as we have felt bound to acknowledge, certain key industrial targets are inescapably involved in modern war, we find no moral distinction between destroying them by tons of TNT or by fire as compared with an atomic bomb, save as greater precision is possible in one as compared with others. But this recognition that we cannot isolate the atomic bomb or even the projected H-bomb as belonging to an absolutely different moral category must not blind us to the terrible dimensions of the moral problem they present.

The abandonment of atomic weapons would not eliminate mass destruction. The real moral line between what may be done and what may not be done by the Christian lies not in the realm of the distinction between weapons but in the realm of the motives for using and the consequences of using all kinds of weapons. Some measures corrupt the users, and destroy the humanity of the victims. Some may further the victory but impair the peace. There are certainly things which Christians should not do to save self or family or nations or free civilization. There seems to us, however, no certain way to draw this moral line in advance, apart from all the actual circumstances. What may or may not be done under God can be known only in relation to the whole, concrete situation by those responsibly involved in it. We can find no moral security, or moral hiding place in legalistic definitions. The terrible burden of decision is the Christian man's responsibility, standing where he does before God.

Nevertheless, real distinctions can be made to illumine and help the conscience in its trouble. The destruction of life clearly incidental to the destruction of decisive military objectives, for example, is radically differ-

ent from mass destruction which is aimed primarily at the lives of civilians, their morale or the sources of their livelihood. In the event of war, Christian conscience guides us to restrain from destruction not essential to our total objectives, to a continual weighing of the human values that may be won against those lost in the fighting, and to the avoidance of needless human suffering.

Unhappily we see little hope at this time of a trustworthy international agreement that would effectively prevent the manufacture or use of weapons of mass destruction by any nation. This should not deter us from the search for such an agreement.

As long as the existing situation holds, for the United States to abandon its atomic weapons, or to give the impression that they would not be used, would leave the noncommunist world with totally inadequate defense. We believe that American military strength, which must include atomic weapons as long as any other nation may possess them, is an essential factor in the possibility of preventing both world war and tyranny. If atomic weapons or other weapons of parallel destructiveness are used against us or our friends in Europe or Asia, we believe that it could be justifiable for our government to use them in retaliation with all possible restraint to prevent the triumph of an aggression. Even if as individuals we would choose rather to be destroyed than to destroy in such measure, we do not believe it would be right for us to urge policies on our government which would expose others to such a fate.

We would, however, call attention to the fact that the first use of atomic weapons in another war, even if limited to sharply defined military targets, would open the way for their use in retaliation. Because of the very power of these weapons, it would be difficult to prevent their use from extending to military targets that would involve also the destruction of noncombatants on a massive scale. If the United States should use atomic weapons, it would expose its allies to similar attack. The nation that uses atomic weapons first, therefore, bears a special burden of responsibility for the almost inevitable development of extensive mass destruction with all its desolation and horror.

Even more fundamental, the dreadful prospect of devastation that must result from any major war illuminates with special clarity, the immorality of those in any country who initiate an aggression against which the only effective means of defense may be the resort to atomic weapons, and which may thus be expected to lead to an atomic war.

Just because the choices open to us on the plane of war appear so tragic and offer so little hope, we are firmly convinced that the way out of our darkness must be sought, not *primarily* by limiting some one or other weapon, but on the political and moral plane. War itself and the malignant sickness of our human relationships are at the center of our trouble.

Though certainly we shall not be saved by weakness, we shall not be saved by military power alone. A one-sided concentration on military measures can easily lead to disaster.

The avoidance of global war without surrender to tyranny is the one great issue overriding all others.

THE REJECTION OF PREVENTIVE WAR

To avoid the physical and moral disaster of global war we must put behind us as a satanic temptation the dangerous idea of a "preventive war," which is closely bound up with the faithless and defeatist idea that war is inevitable.

A fatalism and defeatism which assumes the inevitability of war with world communism deflects us from the very strategy which offers us the greatest hope of any real victory; namely, the building up of the economic and social and moral health of the areas in our world not already under complete communist domination. For communism is more than the tyranny and imperial ambitions of the Soviet rulers. It is also a political religion, whose promises of a universal, classless society, tragically perverted though they have been, still carry a dynamic appeal to those oppressed by harsh and unjust conditions. To overcome such conditions requires positive nonmilitary measures.

Thus to accept the inevitability of war is strategically wrong. It is morally wrong because it is a surrender to irresponsibility. It is religiously wrong because it involves a pretension on the part of man to know the future with an assurance not granted to man.

THE NEED FOR DEMOCRATIC STRENGTH

To build up and maintain adequate strength in the free world will make tremendous moral demands on the people of the United States and other members of the United Nations. For America to maintain over a long period adequate military strength, let alone support bold strategies for strengthening economically and socially our less fortunate neighbors, without the obvious incentive of war itself, will call for self-discipline and resolution and a tightening of our belts such as we have never achieved.

We should not and we do not rule out the possibility of an ultimate stability in the world situation. But we are quite clear that no significant agreements can be made with world-wide communism so long as it assumes that it can violate the decisions of the United Nations with impunity and success. We believe in a moral approach to our problem, but a moral approach is one which accepts responsibly the full burdens imposed by the situation in which we find ourselves.

We believe that peace in our world can be preserved only by the strength of the free world. This includes military power. But moral and political strength is ultimately a larger factor than military strength.

Therefore the faith that sustains American life, and the moral vitality of our society are of supreme importance.

Christians must stand firmly against public hysteria and against all attempts to exploit the fears of our people in these critical days. The sensational or self-righteous distortion of truth, the slanderous defamation of men in public life, the attacks upon hard-won freedoms and the safeguards of our constitution—these divide and weaken our nation in the face of grave external dangers. They point in the direction of the police state methods we oppose. The churches of Christ must stand as guardians of freedom as well as of faith.

Democratic strength requires self-criticism, a willingness to confront the facts with open eyes, and a determination to improve the application of democratic principles to our common life.

And next to the quality of the common life we bring to the issues of our time is the role we are able to play in helping other nations to gain physi-

cal well-being and moral vigor in freedom. The life-giving qualities of the free world, if vigorously renewed, can provide the surest human defense against tyranny and war. If the vitality, integrity, and neighborliness of the democratic societies can be developed and demonstrated in convincing ways, the Soviet rulers may find a modification of their expansionist aims, or at least of their intolerant methods, to be expedient. That would provide new opportunity for bridging the gulf between the Soviet and Western worlds with understanding and more reliable agreements.

Only a bold and imaginative strategy, supported by self-discipline and devotion, has a chance of success. There are no sure patterns of action to enhance the inner and outward strength of the non-Soviet world. Rather, there must be a willingness to try new and uncharted courses of constructive action which offer reasonable promise.

The policies pursued need to be convincing on two basic points. They must carry conviction that the non-Soviet societies are morally impregnable to totalitarian infiltration, as well as militarily strong enough to make overt aggression too hazardous. On the other hand, they must also carry conviction that the goal of the West is peace and not the conquest or forcible conversion of the Soviet Union. This means that the dominant motives of peace strategy should be positive and creative, and that every opportunity to develop friendly contacts with the Soviet peoples, or to draw Soviet representatives into the constructive activities and fellowship of the non-Soviet nations, should be utilized. On this, most Christian pacifists and nonpacifists can agree.

In the forefront of a positive peace program is the plan to provide technical assistance and help secure financial assistance for the development of underdeveloped nations. This plan to attack in a concerted way the ancient enemies, ignorance, hunger, and disease, by concentrating available scientific and material resources on areas of greatest need, has aroused new hope around the world.

In Eastern Asia and the Pacific area there are millions of men struggling up out of poverty and ignorance. There, due to the disintegration of the colonial system, the impact of technical civilization on backward economies, and the resentment of colored peoples against the white world, vast social confusion gives communism a fertile field in which to sow its false promises to desperate peoples. In dangerous measure the Communists have captured the leadership of this revolution of depressed masses against ancient privilege. Rice and land they can call their own and a chance to stand among men in their own right mean more to them than our slogans of freedom or free enterprise. We have to offer them something better than "free privilege" or unrestricted freedom for gain. We need to make it clear that our democratic constitution is Christian in background just because it is founded upon restraints, not upon doctrinaire freedom.

These peoples have suffered for generations the indignity of being treated by white men as "inferior breeds." Just because man is a spiritual being, the indignity of treatment as an inferior rankles more bitterly than physical deprivation. These peoples find it hard to trust us. Their resentments are awakened by every indignity imposed upon Jews or Negroes or Orientals or Mexicans or American Indians. A chance to live as equals and the millennial communist promises of rice and land have fired the awakening hopes of the Asiatic peoples. It is not enough to say complacently that we are working to eliminate discriminations against racial and religious minorities and that it will take time. It will take time, but we need to work at it harder, determined to succeed in the shortest time possible. Renewal of our own way of life and a sustained effort to help the peoples of other lands achieve a better way of life than is possible under totalitarianism—these must be the goals of our strategy.

In Western Europe and the Atlantic area there are the peoples out of which our own inheritance has come most directly. They now stand between the two great centers of power. They fear that if they must be rescued by us they shall be a waste land.

We must give them the confidence that we understand them and how they are placed and that in full truth we make common cause with them. We shall not win that confidence if they can reasonably suspect that we seek to build them up to be buffers between us and the great center of power we fear, instead of seeking the welfare of their peoples for themselves. We and they share a common destiny. Together we are called to meet it in comradeship.

Even in the case of Russia, we cannot afford to accept the assumption that there is nothing human and good and real there to which we could speak. The Russian people share our common human needs and fears and hopes and sensibilities. They too, we are sure, want peace. We must ask ourselves again and again, "Have we exhausted every means of speaking to them and of saying to them that we do not desire to destroy them or to take their land from them or to convert them by force?"

We have no clever new political stratagem to offer. But in the sight of God, we are persuaded that our desperate times call for a mighty and costly drive for the political and moral revival and uniting of the free world and beyond that for reconciliation.

The special task of the churches in our time as in every time is to cry out to men, "Behold your God." It is in beholding Him and in standing in penitence before Him that we can gain and regain our moral stature as responsible men. Before Him we dare to believe that we have a citizenship which no human weapons can destroy.

AAAS MANPOWER PROPOSAL

The American Association for the Advancement of Science reported March 16 that 212 members (80 per cent) of its Council had voted on a manpower resolution submitted to them by those members of the Council who met in Cleveland, Ohio, December 29. The vote for Section A of the resolution was 207 in favor to 4 opposed, and for Section B, 188 in favor to 24 opposed.

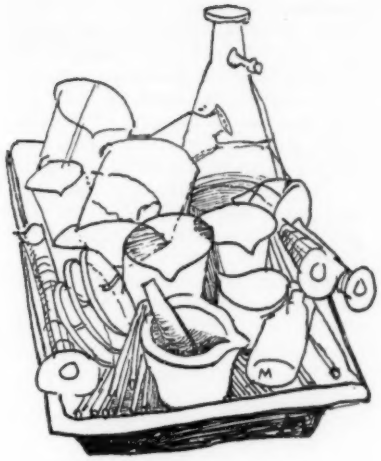
The resolution was as follows:

A. The AAAS affirms with all seriousness and conviction that it would be a national calamity not to make a maximum use in the present emergency of the scientific and technical skills possessed by our trained personnel; and that it would be equally calamitous not to assure an adequate continuing supply of such trained personnel.

B. To achieve these objectives . . . , a system of Universal *National* Service, as distinct from Universal *Military* Service should be instituted, to be administered by a carefully qualified civilian agency that will grant no deferments but will allocate all scientific and technical personnel to such national service as their individual training and skills permit, and national needs require.

EFFECTS OF GOVERNMENT SUPPORT ON SCIENTIFIC RESEARCH

ERIC A. WALKER



The Executive Secretary of the Research and Development Board discusses the scope of the nation's proposed program and its potential effect on scientific and technical manpower.

THE effects of government support on scientific research, and specifically of military support, are rather startling in quantitative terms. Even on the basis of rough estimates, military research and development, including atomic energy research and development, now accounts for nearly two-thirds of the national expenditure for research and development. It is also a little startling to realize that the Department of Defense and the Atomic Energy Commission engage the services of about two-thirds of the nation's scientists and engineers. If the expanded program contemplated by both agencies materializes, we may find ourselves absorbing some three-fourths of the nation's technically trained personnel. The effects of the demand are already making themselves felt in personnel shortages and rising wage scales in scientific and engineering fields.

The size of the military research and development effort is not only startling but sobering. We are confronted by the fact that the greatest portion of the creative thinking and effort of the nation's scientists and engineers is, of necessity, being concentrated on weapons, devices, and techniques of warfare and countermeasures. Not only is the nation as a whole spending a vastly larger sum on research and development than ever in its history, but most of this is going for military purposes. Obviously, this phenomenon is having a profound effect on our culture. There have been diversions and disruptions in the normal fields of teaching and of academic and industrial research. Basic research has been subordinated to applied research and to development, and projects that might have been undertaken in "normal" times have never seen the light of day.

It is not my purpose, however, to contemplate philosophically what the possible effects of these things may be, no matter how strongly we may feel about them. We must adjust ourselves to the realities of the times and look to see whether we can meet the tremendous needs ahead of us. In a sense, the scientist's war service precedes that of the military man because his contributions can only be significant if they are made sufficiently in advance of the state of war to make possible practical manifestations during combat.

It is my intent to examine the scope of our contemplated program in the effort to see what further effects may be expected as far as scientific and technical manpower of the nation is concerned.

GROWTH OF MILITARY EXPENDITURES FOR RESEARCH AND DEVELOPMENT

It is, I think, of some interest to compare the national and military expenditure for research and development in the decade between 1940 and 1950. In 1940 the total national expenditure for research and development was somewhere around $350,000,000, while the military expenditures for research and development were around $22,000,000. By 1945, the national expenditure had jumped to 1.1 billion dollars, and the military expenditures—including those of the Office of Scientific Research and Development—were around $600,000,000. By 1951, one estimate places the national expenditure at 1.75 billion dollars, while another sees it at over two billion dollars. Between 1945 and 1950, the military expenditure for research and development, exclusive of atomic energy, has remained fairly constant and has been in the neighborhood of $550,000,000. The Korean War, which immediately produced requests for a supplemental budget, has also raised the research and development budget to something over 1.1 billion. There is a distinct possibility that before long we may find ourselves operating at almost double the postwar rate of military research and development.

THE EFFECT ON SCIENTIFIC MANPOWER

With that as a hypothesis, and it is as yet merely a hypothesis, let us look for a moment at the potential effects on scientific and technical manpower.

Initially, we can assume that a substantial portion of the increased budget for military research and development is going to be absorbed by rising costs. Material and service costs have risen 19 per cent since 1947. The average salaries of all civil service

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Based on a talk given in Cleveland on December 30, 1950, at a symposium held by the American Association for the Advancement of Science.

workers have risen 13 per cent since 1947. Probably industrial and university salaries have risen comparably. Overtime allotments may be expected to account for as much as a 10 per cent increase in the cost of the program. After taking into consideration the amounts which must be subtracted to take care of inflationary trends, let us assume that a $325,000,000 program will remain to be manned by additional scientists.

One method of estimating such requirements is to divide the $325,000,000 by the average cost per scientist. Recent studies in this field have produced figures sufficiently similar to provide a basis for such an estimate. For the period of 1947 to 1949, the cost per scientist averaged between $10,500 in an industrial laboratory to $15,000 for the Atomic Energy Commission's laboratories, where the cost runs somewhat higher. From these figures we get an annual cost figure of $12,000 per technical employee. Dividing this figure into the $325,000,000, we obtain a requirement of 27,000 additional scientists. This figure represents an expansion in military research and development technical personnel by some 50 per cent and is about 15 per cent of the total national supply of persons thus qualified. These requirements can be met if scientific and technical personnel are recruited from nonmilitary tasks such as teaching and industrial research.

But is this a desirable solution? We cannot raid either our industrial establishments or our schools without deleterious effects on both. A critical aspect of the over-all picture is the diminishing rate of supply of new scientists. Fewer numbers of students are enrolling in the scientific courses in the colleges, a fact that is doubtless attributable in a large part to the decreasing numbers of able science teachers in the high schools. It is these people who play an important part in stimulating the desire for higher education in the scientific fields. The decrease in engineering enrolments is particularly acute.

Another complicating factor at the present time is the extension of selective service. The absence to date of any clear-cut policy on the deferment of scientific personnel has resulted in the induction into the armed services of a number of technical personnel at various stages in their training. In addition, departmental call-ups of scientific reserve officers are cutting into civilian scientific activities. These problems are difficult ones to solve, but the director of Selective Service has several able civilian advisory committees working with him, and we are hoping that an over-all national policy will soon emerge.

The utilization of scientific and specialized personnel within the Department of Defense is yet another aspect of the matter. The Personnel Policy Board of the Department of Defense is working on a policy for the most appropriate assignment of scientists and specialists to military jobs and for their effective utilization in those jobs. If adopted, this policy will help to prevent misassignment of scientific manpower acquired by the services.

The Personnel Policy Board and the military departments are working hard on an analysis of scientific and specialized jobs in the services. This project, together with the New National Science Register, which is the up-to-date version of the old National Roster of Scientific and Specialized Personnel, are the first vital stages in finding out where we stand in matching people with the jobs to be done.

There are no ready solutions to the technical-manpower problem. Additional military research and development have been found necessary under the stepped-up defense program, and additional personnel to accomplish it can be obtained only at the expense of some other activity. For these various activities to compete with each other for the needed personnel would be to produce a disastrous effect upon wages, which in turn would reduce still further the actual funds available for research. Studies have indicated that only 15 to 20 per cent of those trained in scientific, engineering, and technical fields are actively engaged in research and development. Tapping the huge reservoirs of scientists and technical personnel not presently pursuing their professions brings us to the question of some form of national service. This, in turn, is part of the national manpower problem, which obviously cannot be solved overnight.

Some individuals and institutions have taken the initiative in trying to help meet the crisis. The Engineering College Research Council and the Association of Land Grant Colleges and Universities have recently proposed to set up an association to facilitate the procurement of research and development contracts. There is a small but fairly constant volume of mail from both individuals and organizations who indicate their interest in getting into the military research and development picture. Unfortunately, we have not as yet worked out a reliable mechanism for insuring that "buyers and sellers" are brought together in an adequate manner.

ORGANIZATION OF THE PROGRAM

One of the questions we are often asked is: "Is there going to be another OSRD?" I will not say positively that there will be no new OSRD, but I will say that the establishment of such an agency is not immediately contemplated.

At the time the OSRD was established, the funds for military research and development were small, and the army and the navy had separate programs which were unrelated to each other. By the end of the war, the contract for research and development, which was used so successfully by the OSRD, had become an established pattern. Both the army and the navy wrote new contracts with former OSRD contractors to continue work that they had begun under OSRD. Similarly, much new work was undertaken. The Office of Naval Research carried the ball for basic research, and its university program deserves only praise. Each of the military departments has its own program of research and development being carried on both by contract and in service laboratories. We hope that the Research and Development Board has contributed something to the integration of these programs and to an over-all program of military research and development. If the task of coordination is not yet all that we should like it to be, at least we can feel that we have helped to bring about a fruitful cross-exchange of information. The services are not only aware of what each other is doing, but through our civilian committee and panel members, they are aware of relevant work which is being done by industry and universities.

We have also the National Science Foundation, which will fill a conspicuous gap in the national picture.

Most important of all, we have a new sense of awareness of the importance of technology to modern warfare and a mutual respect and understanding between the military and the scientists.

CONSTRUCTIVE USES OF MILITARY RESEARCH

And now, lest I leave the impression that military research and development is a new kind of Juggernaut that is going to grind peacetime scientific projects out of existence, I should

like to point out that not all of the money spent for military research and development goes up in the smoke of battle. Military research, however lethal its intent, nearly always produces something with a constructive application. There are many who would argue, for example, that the medical and biological aspects of atomic energy research have already canceled out the havoc wrought by the atomic bomb.

Biological and chemical warfare, potentially two of the most destructive weapons, have each made important contributions to medical science. Studies of rinderpest, one of the costliest animal diseases in the world today, have produced significant advances in the production of an effective vaccine against this disease. Studies of the action of nitrogen mustards, developed as toxic chemical warfare agents, reveal their remarkable destructive effect upon white blood cells, lymph glands, and bone marrow. These findings suggest their use in leukemia, Hodgkins disease, and lymphosarcoma and have initiated studies that have spread to more than 120 clinics, with hundreds of cases under treatment.

The airborne magnetometer was a gadget developed to aid in the location of submerged submarines. In that respect it proved to be useful in a limited set of circumstances. However, it was found to be much more successful as a tool for geophysical prospecting for valuable minerals and for the determining of geological structures. It is now widely employed by commercial concerns.

Many of the manufacturing techniques now being used in the manufacture of picture tubes for television have resulted from research on cathode ray tubes used for radar. Experimental developments by the military led to a more ruggedized picture tube capable of maximum production in terms of quantity and quality. The technique of sending television signals from one station to another by radio links owes much to the microwave relay links and equipments developed for the armed services for communications purposes during the war.

I could, of course, continue indefinitely with other interesting examples, but these will serve to illustrate the fact that we must train ourselves to a positive and constructive attitude toward the grim world in which we are living. Let us remind ourselves that even while we are busy sowing dragon's teeth we are also sowing good seeds which we hope will yield their harvest in better times than these.

THE U.S. STATE DEPARTMENT AND WORLD SCIENCE

GERHARD J. DRECHSLER

The importance of American encouragement of international science was emphasized in the report, "Science and Foreign Relations," submitted to the State Department by its consultant, Mr. Lloyd Berkner, and summarized in the October 1950 Bulletin. The recommendations included the establishment of a Science Office in the Department of State and of science staffs at diplomatic posts abroad. Recently, Joseph B. Koepfli of the California Institute of Technology was appointed science adviser and H. A. Spoehr of the Carnegie Institution was named consultant for implementing Mr. Berkner's proposal. Other current activities of the department in this field are described in the following article by a member of its Science Policy Survey Group.

SCIENCE, man's fundamental source of material power, like coal or oil, is an irresistible object of national interest. Like coal or oil, it is a natural subject of foreign policy which, as Charles Evans Hughes once cogently reminded us, is ever based upon pragmatic considerations of national interest. Hence it is no surprise that the State Department, this nation's chief full-time agent in the conduct of foreign affairs, is literally "up to its ears" in science. In fact, concern that it should not also be "over its head" in so critical a realm has culminated in the Berkner report on *Science and Foreign Relations* and in current Departmental efforts to give effect to that report's recommendations for the better management of its growing scientific concerns.

These concerns draw significance and direction from the fact that, although it is the world's outstanding user of science, the United States is not self-sufficient in this vital resource. The plain truth is, of course, that no nation, not even the USSR, can be self-sufficient in science. The Iron Curtain is dotted with strategically situated one-way windows behind which unseen Soviet eyes train on the treasures of foreign science. In the words of the Soviet Minister of Higher Education, these eyes "study carefully and evaluate according to merit all achievements of foreign science."[1]

As the world's outstanding user of science, the United States not only profits from but positively depends upon active international cooperation in science. Such cooperation is a national interest of highest magnitude, a major concern of foreign policy, a continuing preoccupation of the Department of State.

SUPPORT OF INTERNATIONAL SCIENTIFIC ORGANIZATIONS

Although principally the work of the scientists themselves, international cooperation in science has required and received steadily increasing encouragement and support from the Department of State. One of its chief functions in this respect is to "pick up the check" for United States membership in international organizations. It does this under the watchful eye of Congress, from whom each year it must win money and support. Such membership last year cost close to $25,000,000, covering fourteen organizations whose work lay wholly or partially in the field of science. Items ranged from fifty dollars, our annual dues in the Central

[1] S. V. Kraftanov, "On the Patriotic Duty of the Soviet Intelligentsia," an address delivered July 10, 1947.

Bureau of the International Map of the World on the Millionth Scale, to the sixteen-million-dollar contribution to the United Nations. Nearly eight thousand dollars went via the National Research Council to the International Scientific Unions, characterized as "the most effective existing international organizations both in promoting fundamental science and in implementing the relation of science to human affairs.[2]

With the "oldest specialized conference unit in the world,"[3] the Division of International Conferences, and with a special, albeit modest, budget, the International Contingencies Fund, the Department of State plays an important role in the support of international scientific conferences. It is a role which varies with each conference, depending on the degree of national interest involved, a matter on which the Department, to the best of its ability, is required to judge. It may draw on the International Contingencies Fund for all United States expenses; it may prepare agenda; brief delegates; help with passport, visa, and travel problems; arrange for transportation and accomodations at the conference site; provide administrative staff; and serve as an intermediary between interested parties in this country and abroad. Last year the Department in varying degrees supported 140 international scientific conferences—a striking contrast to its role in 1938, when the United States took part in only 41 such conferences.

EXCHANGE OF SCIENTIFIC PERSONNEL

The opportunity given scientists for living and working among foreign colleagues—the essence of programs for the exchange of persons—is the outcome of State Department efforts in one of the newest, most swiftly growing fields of government activity. From their beginnings in 1939, government programs for the exchange of persons, run or helped by the State Department, have mushroomed to a point where last year they involved 23,179 persons—18 per cent of all activity in this field. These programs stem from such congressional enactments as the Fulbright Act, the Smith-Mundt—or as it is officially known, the United States Information and Educational Exchange Act—the Philippines Rehabilitation Act, the German Reorientation Program, ECA, MDAP (Mutual Defense Assistance Program), and Point Four. Their science content, varying with program objectives, last year ranged from 21 per cent, or 387 persons, in Fulbright, to 41 per cent, or 142 persons, in the educational phase of the Smith-Mundt program.

In addition to operating government programs, the State Department also helps private organizations with theirs. Its assistance, extended last year to 750 organizations, includes information useful in planning and operating programs; passport, visa, and travel services; and the operation of visitors bureaus, officially called "Orientation Centers," in Washington, New York, Miami, New Orleans, and San Francisco. Scientists coming to the United States on exchange programs of interest to the State Department can avail themselves of customary visitor bureau services at these centers.

AID TO SCIENTIFIC PUBLICATIONS

Most common coin in world-wide scientific exchange are the publications of science, whose circulation the State Department stimulates in the twin guise of broker and investor. As broker, it brings interested parties together and helps negotiate agreements for the exchange of publications. These agreements, some forty of which have been negotiated on behalf of the Library of Congress and the Smithsonian Institution, result in "an annual flow of hundreds of thousands of publications between the United States and other nations, enriching scientific endeavor throughout the world."[4] The Department also plays a liaison role in the program of the U.S. Book Exchange, a private organization which since the end of World War II has placed more than 4,000,000 sorely needed volumes, many of them scientific, back on the shelves of Europe's war-ravaged libraries and institutions.[5]

As investor, the Department annually primes the intellectual pumps of the world with over a million and a half copies of American publications. These go mainly to its world-wide network of 330 libraries, reading rooms, and cultural centers, where about 17 per cent of the material on loan is scientific. Over a half million items of this yearly flow are translations, sent abroad in a program until recently aimed only at Latin America, but now blanketing the entire world. Since the beginning of this program in 1941, over a million and a half translations of American scientific works have been put within reach of foreign scientists.

Prepared under contract for world-wide circulation are monthly State Department newsletters, in medicine, surgery, chemistry, pharmacy, dentistry, and engineering. Basically, the circulation of these newsletters is 78,000 copies, but the figure swells rapidly as many overseas missions translate and reproduce the material according to their on-the-spot needs. The medical society of Guatemala recently abandoned plans to publish a bulletin of its own, deciding to use the Department's medical newsletter instead.

FILMS AND RADIO PROGRAMS

Including over 150 items, the Department's collection of scientific films reaches audiences in many lands. Films on medical and dental subjects make up the bulk of the collection which also covers subjects in physics, chemistry, biology, and engineering.

Even the Department's steadily swelling Voice of America carries word of American science to the rest of the world. Its regularly scheduled science programs have dealt with such subjects as cortisone—itself an outstanding product of international scientific collaboration—gas production from abandoned oil wells and coal mines, and the medical uses of isotopes.

As a contribution to world cooperation in science, the efforts of the State Department just described draw their real significance from the fact that such cooperation is a vital national interest, essential to national progress and prosperity. On it is built the strong and developing science from which alone can come the treasures required by modern nations to protect the margin of their commitment to these objectives. Here, where man can aspire but to work in harmony, lies the challenge to the new, urgently needed instrument of teamwork between scientist and statesman being forged in the fires of the Berkner report. To meet this challenge successfully will carry man farther than he has ever traveled in his age-long quest for peace.

[2] Walter B. Cannon, and Richard M. Field, "International Relations in Science," *Chronica Botanica*, IX (Autumn 1945).

[3] Division of International Conferences, Report to the International Science Policy Survey Group, December 1949.

[4] Dan Marry Lacy, "International Cultural Cooperation," *Scientific Monthly*, LXVI (May 1948).

[5] *Ibid.* As Mr. Lacy points out, most of this work was done on an emergency basis in the immediate postwar period by the American Book Center, progenitor of the U.S. Book Exchange. Current operations are on a more selective basis and hence on a somewhat reduced scale. Since mid-1949 when operations became those of the U.S. Book Exchange, 105,000 volumes have been sent abroad, 60,000 received in return.

NEWS AND NOTES

Prepared by PETER AXEL

THE ARMAMENT DEBATE: LAND ARMIES OR ATOMIC AIR FORCE?

In the recent public and congressional debate concerning American rearmament, only a few voices have been raised against an intensive rearmament drive. The main disagreement has been between those who emphasized the necessity of creating a large army to oppose, if needs arise, any land invasion in Europe (or elsewhere); and those who insisted that aggression can be prevented or defeated by a strategic atomic and nonatomic air force, supported by the domination of the sea by the American navy.

We reprint below excerpts from the statements made in this debate by authoritative military leaders and military writers, particularly in so far as they have dealt with the employment of atomic weapons. Between the official spokesmen, there seemed to be agreement on the following three points:

1. The atomic bomb is a powerful deterrent to Soviet attack now.
2. Despite this, the U.S. must develop a balanced armed force.
3. New tactical weapons, including atomic bombs and improved anti-tank weapons, make it seem possible that Western Europe can be defended against a Soviet invasion despite the vast numerical superiority of the Soviet armed forces.

CONGRESSIONAL HEARINGS

The three members of the Joint Chiefs of Staff testified before the Senate Foreign Relations and Armed Services Committees on February 19. All supported the dispatch of American ground troops. Admiral Forrest P. Sherman and Air Force chief, General Hoyt S. Vandenberg, agreed with Army Chief of Staff General J. Lawton Collins that air and sea power alone could not halt a Soviet attack. Collins said that "the atomic bomb is the greatest deterrent today to war, but I don't think it alone would be the final deterrent." When asked by Senator Wherry whether the United States, with air supremacy, could not destroy Russia by air attack alone, General Collins replied, "You can't do it in a week. In the event of war, our strategic air forces will hit Russia with tremendous might, but that wouldn't prevent Russia from overrunning Europe if we had no land forces there."

General Carl Spaatz, retired Air Force Chief of Staff, and Lieutenant General Ennis Whitehead, head of the Air Defense Command, testified on February 22. While not disagreeing with the sending of ground troops to Europe, they emphasized the need for an enlarged air force. General Spaatz called for 250 air groups. Lieutenant General Whitehead said that "the air force should be given the 'Number 1 priority.' "

INTERVIEWS WITH GENERAL COLLINS AND ADMIRAL SHERMAN

In an interview with the *U.S. News and World Report* editors (February 9), General Collins, U.S. Army Chief of Staff, enumerated four armament programs he considers most important —tanks and anti-tank weapons, anti-aircraft and guided missiles, tactical air support, and air transportation. He said that "We're going to have some guided missiles within eighteen months." However, this will not yet be "the whole family of guided missiles." He stated that it was "wholly possible" that atomic explosives would be delivered by artillery in the "not too distant" future. Admiral Sherman, in an interview in the February 23 issue of the same journal, confirmed that all the services were developing "tactical applications of atomic weapons." The navy, he said, will be prepared to use atomic explosives in the form of both missiles and airplane-carried bombs.

VANNEVAR BUSH SPEECH

Dr. Vannevar Bush, president of the Carnegie Institution of Washington, gave a radio address on March 4, 1951, under the auspices of the Committee on the Present Danger. The following are portions of the text:

"At the end of the war our allies were exhausted. We disarmed. We know what has happened. Russia moved in. But Russia stopped at the boundary where the Kremlin was sure there would be war with us if it proceeded further. We saw the matter tested out at the time of the airlift in Berlin.

"The deterrent is nearly as powerful today as it was then. If Russia sent its armies rolling across the German plains tomorrow, we with our A-bombs and the planes to carry them would destroy Russia. We could do it without question, as matters stand today. We could destroy not only the key centers from which her armies would be supplied, but also political centers and the communications of the armies on the march.

"The difficulty is that we cannot count indefinitely upon strategic bombing as the sole means of averting war. Today, it gives us a military stalemate. To maintain that stalemate is the real problem.

"Defenses against strategic bombing have been mounting ever since the war. Jet pursuit ships controlled by ground radar can be enormously effective in bringing down high-flying bombers. Russia with its vast distances can have extensive early warning radar networks to alert its defenses. She can have great fleets of jet pursuit ships for defense, accurately controlled from the ground night and day. She can also have about her key positions modern anti-aircraft artillery and also perhaps ground-to-air guided missiles.

"Russia in time can thus protect her key points. Note that I say in time. She cannot do it now. She cannot at any time safeguard all the places in

Russia we might wish to attack. But in time there is a strong probability that she can defend key points to the extent that we could not penetrate to them without prohibitive attrition. She is also building a stock of A-bombs of her own. The deterrent of our A-bombs is real. But we cannot count on its remaining fully effective forever. I trust we have time—time to prepare the defenses that will continue the balance and avert war. But we do not have time to waste.

"In the first place, take the matter of tanks. Russia has 40,000 tanks of various sorts. But there have been developed in the last few years anti-tank weapons of great power. Relatively small recoilless anti-tank guns mounted on a jeep or handled by four men can put a heavy tank out of business. These guns can be built in quantity by the hundreds for the cost of a single heavy tank.

"I do not say that the big tank is now obsolete; I do say we can make it obsolete if we put our minds to the job and build the things to counter it.

"There is another factor, moreover, which is of enormously great importance. Out in the Nevada desert there have recently been a number of explosions. Presumably they mean the testing of new types of A-bombs developed by the Atomic Energy Commission during the past five years.

"We have thought of the A-bomb as a means for attacking great military production facilities or centers of political power. The A-bomb can also have important tactical uses. Suppose that a war were to break out three or five years from now and that the Russian hordes were held up by a much smaller number of well-disciplined and well-armed divisions. If the line were not too thinly held, if it were defended in depth with the land mines, anti-tank obstacles, artillery, and other weapons that we can have if we choose, how would the Russians break it?

"They could do so only by a huge concentration of armies, artillery, and tanks—the kind of thing the Nazis did in 1944 just before the Battle of the Bulge. But with A-bombs in existence this becomes a very different matter. An A-bomb delivered upon such a concentration by an airplane, or possibly by use of a gun or a guided missile, would be devastating. In its presence, concentration of this sort would not make sense. Tactical use of the A-bomb thus will help to make the defense of Europe with reasonable numbers of men a practicable matter."

EISENHOWER'S TESTIMONY ON EUROPE

The testimony of General Dwight D. Eisenhower before the Senate Foreign Relations and Armed Services Committees has not been officially released; the following quotes are from a United Press report whose source has not been revealed, but whose authenticity has not been questioned.

"To my mind the use of the atomic bomb would be on this basis," General Eisenhower said.

"Does it advantage me, or does it not, when I get into a war? Now, if I felt that the material destruction that I was going to accomplish was not equal to some moral or great reaction otherwise to this act, then I would abstain.

"If I thought the net was on my side, I would use it instantly, because I proceed from this basis: The United States is not going to declare war or conduct an aggressive campaign. It is merely going to defend itself, and if someone, in spite of its peaceful purposes, jumps on it, I believe in using what we have in defending ourselves."

He made clear that long-range bombing, super-modern equipment, including atomic weapons and control of the seas were the vital factors in winning any war with Russia.

HANSON BALDWIN'S OPINION

Hanson W. Baldwin, military analyst of the *New York Times*, wrote in an article published on February 9:

". . . Continued . . . insistence upon an atomic strategy as the key to victory can be both politically and militarily dangerous if it is overdone. There is no doubt that our lead in the atomic race does give us a military advantage that cannot be despised or ignored, and there is no doubt that our ability to retaliate quickly and heavily with an atomic bombardment against the heart of Russian industrial potential can be a deterrent to aggression.

"But the A-bomb has distinct military and political liabilities; it is not a military cure-all; it provides no absolute security. . . . As Korea has shown, [it] has but limited military or political utility in . . . war in an undeveloped country. . . .

"Nor is the A-bomb a certain guarantee of victory if general war should come . . . our atomic superiority probably could not halt the Soviet army tomorrow if it started to roll across Western Europe, could not save Yugoslavia if she were invaded in the spring. . . .

"But the greatest weakness of a . . . primarily atomic strategy is that it might put the major emphasis upon winning the war at the expense of winning the peace. Obviously you cannot win the peace if you lose the war, but you can lose the peace even if you win the war (as our experiences since World War II demonstrate) by concentrating too much upon the strategy for victory and not enough upon the political aims of victory.

". . . . We must first chart the kind of world we want, and then and not until then, should we outline the strategy we should follow to win a victory if we have to fight a general war to get that kind of world."

COLONEL W. R. KINTNER'S STATEMENT

In support of his views, Baldwin quoted the following conclusions reached by Lieutenant Colonel W. R. Kintner (U.S. Army) in an article in the *Proceedings of the Naval Institute* (March 1950):

"We cannot risk a military policy which might drive potential allies into neutrality or hostility.

"We cannot employ any and all kinds of weapons without regard to the postwar consequences of their employment.

"We cannot permit the public utterances of American atomic air power advocates to provide a logical excuse for totalitarian aggression.

"The cold truth is that we must, if driven to it, be prepared today to wage an atomic war as well as war on pre-Hiroshima lines.

"Our military plans must recognize that the only sound objective a free people should have in war is to win a victory that will expand, not contract, the map of freedom."

ATOMIC SPIES: A SUMMARY OF THE TRIALS

The first espionage trial in the United States involving the betrayal of atomic bomb secrets began on March 6 and ended on March 29 with the conviction of the three defendants. On April 5, Mr. and Mrs. Julius Rosenberg were sentenced to death and Morton Sobell to thirty years' imprisonment for conspiring to pass military secrets to Soviet Russia during wartime. On April 6, David Greenglass, who had been convicted earlier, was sentenced to fifteen years.

In sentencing the two defendants to death, Judge Irving Kaufman has followed the interpretation placed by the chief prosecuting attorney, Irving Saypol, on the statute providing the penalty of death for spying in wartime. Mr. Saypol argued that the law, in imposing a heavier penalty in wartime, did not intend to restrict this penalty to spying on behalf of the enemy in a war and that, therefore, the fact that the Soviet Union at that time was a military ally in the war against Germany is not relevant to the application of this law. The defense attorneys have announced that the decision will be appealed, and in all probability the last-mentioned legal point will be one of the subjects on which the higher court will have to make a final decision.

Mr. Greenglass, Mrs. Rosenberg's brother, testified on March 9 that he was a defendant in the same indictment and had pleaded guilty. He had been a machinist at Los Alamos, working on the bomb fabrication under Dr. George B. Kistiakowski of Harvard University. Using a sketch, which he said was similar to the one he had given Rosenberg, Greenglass described the construction of the "Nagasaki type" bomb.

According to him, it contained thirty-six high explosive "lenses," curved high explosive molds, each with two detonators. When the lenses were detonated, the explosive force was directed inward, pushing plutonium into a small enough volume so that a chain reaction would start.

Greenglass then described three concentric spheres inside this shell of lenses. The outermost was a "barium plastic sphere," next came a plutonium sphere, and inside it a beryllium sphere which "provided a source of neutrons." The earlier "Hiroshima type" bomb consisted, according to him, of two pieces of fissionable material inside a "gun," one of which was shot into the other to bring together the "critical" mass.

SOURCE OF INFORMATION

Mr. Greenglass said that he did not originally know the nature of the work he was doing at Los Alamos, but that Mr. Rosenberg—who himself had no relation to the atomic bomb project—had explained it to him long before the Alamogordo test and had asked him to gather information on the mechanism of the bomb from his co-workers in the bomb workshop, an assignment which he agreed to undertake after brief hesitation. Mr. Rosenberg had also known in advance about the intended test at Alamogordo.

The explanation for this information's allegedly being in the hands of Mr. Rosenberg at the time when the nature of the "Manhattan Project" was a deep secret may be found in the fact that the present trial has been the consequence of the revelations by Klaus Fuchs, a British theoretical physicist who worked at Los Alamos.

In the trial which led to his being sentenced last year by the British court to fourteen years in prison, he admitted having systematically provided Soviet agents with reports on the progress of the British-American atomic energy project, and he described the persons in America who served as intermediaries between him and the Soviet leaders of the spy ring.

HISTORY OF ARRESTS

The first arrest in this country was made when Harry Gold was apprehended on May 23. He was indicted on June 9, charged with conspiracy to violate the Federal Espionage Act and with eleven specific instances of spying. Gold pleaded guilty on July 20, and was sentenced to thirty years in prison on December 8. He admitted having been a courier for Fuchs and having also received data from Greenglass.

The second member of the same organization, Alfred Dean Slack, a chemist, was arrested on June 15; on September 1, he was indicted and charged with giving Gold samples of a new explosive, RDX. Slack, who had been employed at the Holston Ordinance works in Tennessee, pleaded guilty on September 18 and was sentenced to fifteen years in prison three days later.

The arrests of the three present defendants also occurred last summer: Greenglass was arrested on June 16, Rosenberg on July 17, Mrs. Rosenberg on August 11, and Sobell on August 18. Mrs. Greenglass, named by the grand jury as a co-conspirator, was not arrested nor indicted; she appeared together with Mr. Greenglass as prosecution witness in the present trial.

Indictments were also handed down by federal grand juries against several persons for having obstructed justice during the course of an earlier grand jury investigation in 1947 and implied that they were partially responsible for the government's inability to discover the spy ring at this earlier date. Mr. Abraham Brothman and Miss Miriam Moskowitz were indicted on July 29, 1950, one day before the three-year statute of limitations would have prevented their prosecution. Their trial began on November 10, with Gold as the chief government witness. They were convicted on November 22. Miss Moskowitz was sentenced to two years in jail and fined $10,000. Mr. Brothman, who was charged with conspiracy to defraud the government as well as with obstructing justice, was sentenced to seven years in jail and fined $15,000. The sentences were the maximum allowed for the charges.

The third accused in this group, Oscar John Vago, was indicted on September 28, charged with perjury before the 1947 federal grand jury. Mr. Vago has pleaded not guilty and has not yet been tried. The fourth indictment, announced on March 13, charged William Perl, an aerodynamics expert at Columbia University, with perjury for denying under oath that he was acquainted with the accused in the Greenglass-Rosenberg trial. The searchlight also fell on Sanford Lawrence Simons, a technician who admitted stealing some plutonium while working at Los Alamos in 1946; no allegation was made that this theft of government property had any relation to espionage activities. Simons was sentenced to eighteen months in prison.

SCIENTIFIC STATUS

Because of the repercussions which these trials had on the public opinion concerning scientists, it is worth pointing out that of the five Americans charged with espionage only one, Greenglass, worked on the atom bomb project, and that he was not a scientist but a machinist and technical sergeant in the army. Of the defendants convicted or accused in connection with nonatomic activities of the espionage ring, one, Slack, was an industrial chemist, hardly qualified as a "sci-

entist." Perl, an aerodynamic expert, qualifies for this title, but it remains to be seen whether any actual participation in treasonable activities will be imputed to him.

This sets the record straight but it does not mitigate the importance of the fact that two prominent members of the scientific group associated with the bomb project, the British physicist, Allan Nunn May, and the British-naturalized German theoretical physicist, Klaus Fuchs, have been guilty of espionage on behalf of the Soviet Union and that Fuchs, in particular, an avowed Communist, had been able to keep the Soviet government fully and competently informed on the most important aspects of the British-American projects almost since their inception.

* * *

ATOMIC ENERGY IN ARGENTINA

President Juan D. Peron announced March 24 that scientists in Argentina had produced "controlled liberation of atomic energy" by thermonuclear reactions without the use of uranium.

The new method, he said, was much cheaper than nuclear fission and he indicated that scientists who have discussed the hydrogen bomb elsewhere have been "enormously far" from correctly understanding their problem.

Most scientists in this country who commented on the announcement viewed it with extreme skepticism. The text of the 10,000-word statement released by Dr. Ronald Richter, Austrian chief of the Argentine project, has not reached us yet, but according to newspaper reports he has somewhat hedged on Peron's claims by saying that the project so far has been only on a "lab scale."

ULTIMATUM RECONSIDERED

The *Bulletin* has learned from Marcus T. Neeley, chief enforcement officer in Chicago of the U.S. Office of Immigration, that a recent decision to refuse extension of visas after April 15 to a group of approximately thirty Chinese students at Midwestern universities is now being reconsidered. About half of them, Mr. Neeley said, are science students.

The *New York Times* stated March 24 that throughout the United States more than three hundred Chinese students completed their work in midterm and that at least five hundred more will have done so at the end of this school year. Their permits to stay in this country depend upon their being students.

They cannot remain here and accept full-time employment unless action is taken on their behalf by the Department of Justice, and according to the *Times*, the department is "fully empowered by congressional action to promulgate regulations under which these students may make a living in this country. The department's action should be taken therefore without delay. It would be manifestly criminal to compel their return to Communist China, since a very large percentage of them are strongly anti-communist."

NEPA PROJECT

On February 22, the air force and the AEC announced that the NEPA Division of the Fairchild Engine and Airplane Corporation has "completed its contract" for studies of the feasibility of nuclear-powered aircraft. It will be terminated on April 30, after four years of work. It was announced without amplification that "other projects" supported by the AEC and the air force in the field of nuclear-powered flight "will be continued."

On February 23, the Associated Press reported the statement by a General Electric spokesman that "contractual negotiations are under way between General Electric and the air force for the development of a nuclear power plant for aircraft" at the gas turbine division of the General Electric at Lockland, Ohio.

This report was widely heralded as indicating that nuclear-powered airplanes are slated for the near future. No authentic support for such optimistic utterances is available. At the AEC press conference on March 12, the Chairman, Gordon Dean, said that the AEC had "not yet decided" whether they wanted "to enter into any kind of contract" in this matter. However, by March 25, the AEC did report that contract negotiations with General Electric had been authorized.

URANIUM PROCUREMENT

Sumner Pike, Commissioner of the AEC, announced at a press conference on March 12, that uranium production has "been very encouraging." Last year, U.S. production "exceeded that of Canada," and (as far as is known outside Russia) is now "second only to that of the Belgian Congo." This production comes from medium and low-grade ores, particularly in the Colorado Plateau. On February 28, the AEC announced a new bonus and a more liberal price guarantee for ores with uranium oxide content above 0.1 per cent. The old bonus plan, which will continue, applied only to high-grade ores (over 20 per cent uranium oxide); no prospectors have yet been able to qualify for this bonus. Another potential source of uranium, whose extent has not been disclosed, was referred to in an AEC release on February 21. It announced that a process had been developed for extracting uranium from phosphate rocks as by-product of fertilizer production, although the uranium content of these rocks is very low.[1]

DEFERMENT ORDER

In an executive order March 31, President Harry S. Truman authorized deferment of certain students when their study is considered necessary for national health, safety, or interest, and when any of the following conditions exist:

1. They have been admitted to or are students in professional schools of medicine, dentistry, veterinary medicine, osteopathy, or optometry and have been certified by their schools to be satisfactorily pursuing a full-time course leading to graduation.
2. They are full-time graduate students certified to be meeting degree requirements and expected to attain their degrees.
3. They have been accepted for admission to graduate schools or to colleges or universities for the class next commencing for full-time work, or are satisfactorily pursuing such course, and within categories prescribed by the Director of Selective Service with approval of the President, either have maintained required scholastic standings or have attained satisfactory scores on a test (prescribed as above), or both such standings and scores.

APPOINTMENTS

Dr. Alan T. Waterman, technical director of the Office of Naval Research, was selected by President Truman, on March 9, for the post of the first director of the National Science Foundation from a slate of seven submitted by the foundation's twenty-four-member advisory board.[2] Before joining ONR in 1947, Dr. Waterman was a member of the National Defense Research Committee and of the Office of Scientific Research and Development.

[1] See *Bulletin*, January 1951, page 31, for other recent news on uranium procurement.

[2] For a complete list of the members of the advisory board of the NSF see *Bulletin*, December 1950, page 380.

CIVIL DEFENSE NEWS

FEDERAL APPROPRIATION

Millard F. Caldwell, head of the federal Civil Defense Administration, announced February 23 that his offices were embarking on a program to mobilize 20,000,000 trained persons, and President Truman asked Congress March 1 for $403,000,000 for the Civil Defense Administration. Of this, $128,000,000 was to be used for operations, $250,000,000 for protective facilities, and $25,000,000 for the civil defense procurement fund.

MUTUAL AID

After a trip to England in February, Mr. Caldwell said that he was negotiating for the loan of experienced instructors from Britain to help train U.S. volunteers, and that conferences had been held with Canadian authorities and were scheduled with Mexico. Exchange of training personnel with Canada and identical warning codes and terminology had been planned.

Agreements were ratified by the New York State legislature for mutual aid between neighboring states; Colorado, New Mexico, Texas, Oklahoma, Kansas, and Arizona initiated interstate pacts for formal ratification; and Utah entered into agreements with Colorado, Arizona, and New Mexico.

Six New Mexico cities, including Santa Fe, Albuquerque, and Los Alamos, began discussions of mutual community aid agreements.

THE NATIONAL SHELTER PROGRAM

The federal Civil Defense Administration was confronted with negative reactions by a number of states to the 50–50 fund-matching provision[1] for communal shelter finance prescribed by the federal Civil Defense Act and to the stipulation in the act that federal money should balance state funds only if communal shelters are to be used for no other purpose than civilian defense.

Interpreting the Civil Defense Administration's views on the shelter program, Mr. Caldwell told state directors February 12 that matching federal funds would not be available for individual or family-type shelters and that contributions will not be made for any shelters outside critical target areas. Budget estimates are now being prepared for Congress, he said. In the meantime, each state director was asked to take an inventory of existing structures for shelter use.

Generally, he stated, the CDA is considering four types as eligible.

1. Conversion of existing buildings or structures owned by the state or a political subdivision thereof. Buildings operated for revenue will require a ruling by the Comptroller General before a definite decision can be issued. Such a ruling is being requested.

2. Conversion of existing buildings or structures owned by private persons. Again a ruling will be needed.

3. New dual-purpose structures which could be used in part for other purposes. Contributions here are limited to the matching of funds for the civil defense features only.

4. New single-purpose communal shelters.

Under the act, he pointed out, the law imposes no restriction on sources of funds, and the responsibility for arranging the financing rests on the states and cities.

He suggested that the British example be followed of using available structures rather than building deep community ones. They may not be as safe, he said, but it is hard to say if any shelter would be safe in the event of an atomic blast. He reported that the engineering school at Lehigh University is studying requirements for reinforcing buildings.

STATE REACTIONS

New York State's Military Law Committee refused February 27 to request any state appropriations for matched-fund shelter construction unless Congress revised the act, in spite of the fact that the federal adminstration had tentatively set aside 250,000,000 dollars to match a like amount from New York State. By March 18, however, the state legislature had approved state aid to the extent of 25 per cent of costs for shelters, subject to federal aid of 50 per cent, and authorized use of $25,000,000 from the state's capital construction fund. But it was believed in Albany that nothing would be done until the single-purpose federal stipulation was rescinded.

The reluctance of New York State officials to embark upon a shelter program was reflected by Lenox R. Lohr, Illinois director, who claimed January 23 that for Illinois to build a large number of communal shelters would be a waste of money since people could not get to them fast enough and because he believed that the few which should be built in strategic locations should be entirely financed by the federal government, as an attack on the state of Illinois would be an attack against the United States as a whole.

Also in Illinois, a conference of twenty state governors, meeting in Chicago, January 26, recommended a review of the entire question of shelters before any state or federal funds are appropriated.

Governor Alfred E. Driscoll of New Jersey objected January 12 that the matched-fund federal program would cost his state $48,000,000 and that increased taxes for this would discourage the establishment of new war industries there.

CITY DIFFICULTIES

Concurrently, mayors of New York State, in conference in Albany, asked that only a nominal percentage of the cost of shelters be charged to the municipalities "because the shelters are necessary to the nation and the state." They said that the danger of further inflation was threatening cities and villages already in straitened circumstances.

The snag in the small shelter program, New York City discovered, was getting building owners to allow the use of their buildings. They seemed to feel they might be held liable for accidents to persons in the shelters during raids and feared damage to their buildings and thieving by the occupants of the shelters, according to Commissioner Bernard J. Gillroy, shelter chairman, January 13. A proposed law to make shelters in tenanted buildings mandatory was being considered by the city's corporation counsel.

NEW YORK STATE LAW

Beside its allocation to the shelter program, New York State passed a bill in March, setting up a twenty-three-member State Defense Council and a thirteen-member state commission with powers to mobilize manpower and materials, to conscript persons, and to remove officials from office in time of actual or imminent attack; authorized workmen's compensation for volunteers injured in training and state coverage for them in the event of an attack; and approved stockpiling of $10,000,000 worth of medical supplies.

[1] See *Bulletin*, VII (February 1951), 60.

(*Continued from page 101*)

birth rates. The organization of their economic, community, and familial life; their normative orders of religious and moral sentiment; their educational systems; and the means by which men and women gained status with each other and with their fellows were all oriented in mutually supporting fashion to provide ample reproduction. Such arrangements are woven tightly into the social fabric and are slow to change.

As a rule, they change under the impact of urban and industrial development. In the Western world, factory employment and the other complex arrangements of modern city life have taken away many of the economic, educational, and recreational functions of the family and larger relationships. Women have found new alternatives to early marriage and continuous childbearing as a means of providing livelihood and prestige. Popular education has weakened the hold of old taboos and widened the horizons of knowledge and aspiration. In mobile city populations, the individual has come to be judged much less by the station into which he was born and much more by his abilities and possessions. Gradually, the primary importance of the family and of larger kinship groups has given way to new emphasis on the welfare and opportunities for advancement of the individual. With the emergence of new aspirations for the children, training became expensive, and opportunities for economic contributions by children decreased. Under these multiple stimuli, old ideals, centering on a large family, began to give way to the new ideal of a small number of children, for whom better opportunities could be provided. As a result, the rational control of fertility, mainly by means of contraception, began to spread throughout the modern societies, bringing in its train the low birth rates with which we are familiar in the Western world.

Thus the societies that produced the modern technology which reduced mortality were eventually transformed by the very requirements of that technology in ways that ultimately led to a somewhat comparably low fertility. The interval of transition, during which death rates led the birth rates in the downward trend, was one of sustained and very rapid growth. In Japan, where urban-industrial development began much later, the essential elements of the process are also evident. Here the techniques were borrowed, but borrowed wholesale and self-imposed with, to date, very similar results. Here too, however, it may be doubted that the period of transition will be completed without a three or fourfold multiplication of the initial population or, alternatively, a catastrophic loss of life.

Throughout most of the Far East, the situation is quite different. There, colonial and semi-colonial populations have borrowed, or have had forced upon them, a few of the Western techniques of government, transportation, agricultural production, and epidemic control. These have reduced mortality somewhat, but have left the majority of the people untouched in the essentials of their daily lives. The people work and live in much the same conditions as their ancestors did before them and retain the familial organizations, beliefs, and interests that have served throughout the ages to maintain high birth rates. Borrowed techniques and borrowed technicians have enhanced economic production with a minimum of disturbance. Unfortunately, the very lack of disturbance testifies to the failure of the new techniques to develop the deep roots in the social order that a healthy transplant requires. It testifies also to an absence of the social reorientation from which the small family ideal may be expected to emerge.

The result of a century and a half of limited economic development in the Far East has been huge population growth. It would be difficult to prove, however, that the people of China, India, Java, and analogous areas are today better housed, better clothed, or better fed than they were a century and a half ago. In some regions they are less likely to be killed by bandits, or perish in tribal wars, or fall victim to the most virulent of epidemic diseases; and they are perhaps less likely to starve to death in a major famine.

If death rates can be reduced, this base population of a billion stands poised for rapid growth—growth that could within a century swell their numbers to equal the present population of the world. Thus, limited economic development imposed from the outside, on the one hand, reduced the space available for future expansion, and, on the other hand, increased the expansion that must be faced before a satisfactory equilibrium can be attained.

CONCLUSIONS

Three general conclusions seem obvious if our object is sustained improvement in the health of the world's poorest peoples.

1. The economic need is enormous. It is much greater than the need for expanding production to meet the minimum requirements of growth kept slow by wretched health. Instead, the need is for production that yields rising levels of living for rapidly expanding numbers during a period of transition to low birth rates.

2. Economic development is necessary, but not sufficient. We have already had ample demonstration of the failure of agrarian development that left the social supports of high fertility intact. The populations are now too large to permit reliance on the automatic processes of urban-industrial development for transition without an intervening catastrophe. These risks would be much lessened if a downward trend in the birth rates of the peasant populations could be induced at an early date. Such a trend would be fostered if a new emphasis could be placed on the importance of health, education, and opportunities of individual men, women, and children, so as to strengthen the ideal of the small family; and if simple, cheap, and effective contraceptives could become available to simplify the attainment of that ideal.

3. Finally, on the matter of outside aid from technologically advanced populations, experience teaches important lessons about the risks of imposed and unbalanced progress. Aid, if it is to be useful, must be manysided. The most concrete projects are not necessarily the most practical ones. It is dangerous to give societies the products of modern technology in ways that permit them to avoid undergoing the social changes that the indigenous development of their own production would force upon them. Aid that gives training, advice, and demonstration is extremely important; but, if the innovations are to take root in the society, actual operation by the people themselves seems equally important. Technical aid for balanced modernization by the people themselves, supplemented by direct efforts to reduce the fertility of the peasant population, offers the major hope for sustained improvement in the health of the world's neediest people.

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